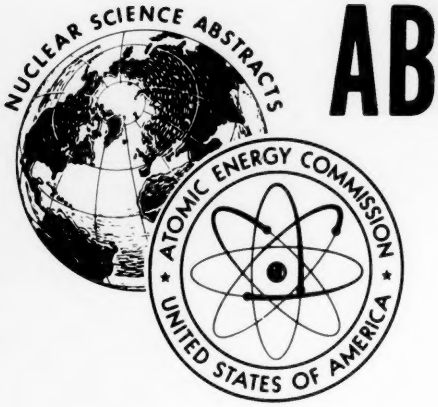
# NUCLEAR SCIENCE ABSTRACTS



Volume 27 Number 10

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May 31, 1973

UNITED STATES ATOMIC ENERGY COMMISSION

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Volume 27, Number 10, May 31, 1973

# NUCLEAR SCIENCE ABSTRACTS

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*Published by the USAEC Technical Information Center, Robert L. Shannon, Manager.*

*Nuclear Science Abstracts* provides the only comprehensive abstracting and indexing coverage of the international nuclear science literature. It covers scientific and technical reports of the U. S. Atomic Energy Commission and its contractors, other U. S. Government agencies, other governments, universities, and industrial and research organizations. In addition, books, conference proceedings, individual conference papers, patents, and journal literature on a worldwide basis are abstracted and indexed. Each issue of *Nuclear Science Abstracts* includes four indexes: subject, personal author, corporate author, and report number.

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**NEWCOMB, William A.,** Stability of a magnetic well, 25:1239
**NEWKIRK, L. R.,** Superconductivity in the pseudobinary
  alloys $V_3Si$--$Nb_3Al$, 25:1093 (CALT-822-13)
**NEWLAND, E. A.,** Radiation treatment of sewage, 25:140
  (AAEC/LIB/Bib-254)

## Subjects

The subject index consisting of specific materials, objects, and processes is arranged alphabetically. Modifying phrases specific to these subjects in turn are arranged alphabetically under the subjects.

**TRANSURANIUM ELEMENTS**
  determination in bone ash, radiochemical method for,
    25:40 (IDO-12073, pp 28-36)
  separation by ion exchange and complex-formation elution,
    25:251(P)
**TRIETHYLENETETRAMINE**
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    radiation effects on labeled, thermal-neutron, 25:137
**TRITIUM**
  content in Cattaraugus Creek near West Valley Processing
    Plant, July through Dec. 1969, 25:258 (DOCKET-50201-
    48)
  content in Cattaraugus Creek near West Valley Processing
    Plant, Jan. to July 1970, 25:259 (DOCKET-50201-49)
  determination in luminescent material by scintillation
    ccunting. 25:40 (IDO-12073, pp 28-36)

## Corporate Authors

Technical report literature is indexed from the name of the organization or institution responsible for the issuance of the report.

372 (UCRL-72739) CONSTRUCTION OF A UNIQUE UNDERGROUND WHOLE BODY COUNTER. Griffith, R. V.; Anderson, A. L.; Lindeken, C. L. **(California Univ., Livermore. Lawrence Radiation Lab.).** Oct 1970. 27p. (CONF-701009-1). Dep. NTIS.

is indexed as:

**CALIFORNIA UNIV., LIVERMORE. LAWRENCE RADIATION LAB.**
  Construction of a unique underground whole body counter,
    25:372 (UCRL-72739)

## Report Numbers

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```
ORNL-
  4270(Vol.2) 25-614    Dep. NTIS
  4606        25-1530   Dep. NTIS

ORNL-IBP-
  70-3        25-2025   Dep. NTIS

ORNL-IIC-
  21          25-261    Dep. NTIS
  30(Pt.2)    25-331    Dep. NTIS

ORNL-NSIC-
  78          25-1912   Dep. NTIS
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Information on the availability of the published literature and unpublished conference papers abstracted in *Nuclear Science Abstracts* can be obtained from the USAEC Technical Information Center, P. O. Box 62, Oak Ridge, Tennessee 37830.

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Volume 27, Number 10 May 31, 1973

NUCLEAR SCIENCE ABSTRACTS

# CHEMISTRY

## Analytical Chemistry

*Refer also to abstracts 22536 and 22942–22944.*

**22041** ACCUMULATION AND DISTRIBUTION OF ELEMENTS IN PLANTS. Peterson, P. J. (London Univ.). pp 323-341 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

Most of the naturally occurring elements of the Periodic Table that have been detected in plants are reviewed and their concentration ranges illustrated. The methods of chemical analysis are assessed. Special attention is given to copper, zinc, cobalt, and to the so-called "newer essential elements", e.g., selenium, chromium, nickel, and tin, which may be required by man and some animals. Some elements, e.g., fluorine, lead, mercury, arsenic, and cadmium, which are found in plants at concentrations toxic to animals, occur naturally at high concentrations in some areas. The relation of these to pollution is discussed. Accumulation is considered to include both the occurrence of a higher concentration in plants than in soil, and a higher concentration in a plant taxon than is common in plants generally. Accumulation is illustrated in both higher and lower plants. The relation of accumulation to essentiality is considered. Special attention is given to the concentration of elements in the plants of those specialized communities growing in soils over ore bodies and in mine wastes. The inheritance of the ability to accumulate and the relation of this to plant taxonomy is discussed. The development of the concept of biogeochemical prospecting is outlined and compared with geobotanical prospecting. The usefulness of radioactive isotopes in determining the relative distribution of some elements in different plant organs, cell organelles, and tissue fractions is described with relation to the elements $^{75}$Se, $^{51}$Cr, $^{65}$Zn, and $^{63}$Ni. Finally, the chemical nature of the elements in some unusual accumulator plants will be mentioned with reference to valence, chemical structure, and metabolism. (auth)

**22042** DEVELOPMENT OF ANALYTICAL CHEMISTRY IN 1970 (REVIEW). Pilipenko, A. T.; Volkova, A. I. Ind. Lab. (USSR) (Engl. Transl.); 38: No. 4, 485-511(Apr 1972).

Translated from Zavod. Lab.; 38: No. 4, 385-407(Apr 1972).

Topics considered in a review on methods of chemical analysis are: extraction, atomic absorption and spectral analysis, chromatography and ion exchange, new organic reagents, and methods and problems in analytical chemistry. Reactions and methods for the determination and separation of specific elements and compounds are given. (368 references) (DHM)

### Activation and Nuclear Reaction Procedures

*Refer also to abstracts 22620, 22798, 22817, and 22818.*

**22043** (CONF-721010-34) STUDY OF THE DISTRIBUTION OF IMPURITIES INSIDE MATERIALS USING CHARGED PARTICLES. Krasnov, N. N.; Konstantinov, I. O.; Malukhin, V. V. 1972. 11p. (In Russian). Dep. NTIS (U. S. Sales Only).

From International conference on modern trends in activation analysis; Saclay, France (2 Oct 1972).

A charged particle activation method enabling the distribution of impurities inside a material to be investigated is presented. A quantitative distribution for the oxygen in Ge and Nb samples was obtained experimentally using 75 MeV $^{3}$He ions. (France)

**22044** (CONF-721010-36) CHARGED PARTICLE ACTIVATION ANALYSIS APPLIED TO THE DETECTION OF HEAVY ELEMENTS. Riddle, D. C.; Schweikert, E. A. 1972. 6p. Dep. NTIS (U. S. Sales Only).

From International conference on modern trends in activation analysis; Saclay, France (2 Oct 1972).

Trace analysis methods were developed for determining thallium, lead, and bismuth. Proton or deuteron activation was used followed by a radiochemical separation of the reaction products: $^{203}$Pb from thallium, $^{206}$Bi from lead, and $^{207}$Po from bismuth. Activation curves are presented for different nuclear reactions occurring on the element studied. Determinations were carried out on high purity samples $X_1$ (glasses doped with trace elements) containing varying amounts of thallium, lead, and bismuth. The detection limits are estimated at 0.01 ppM for lead, and 0.001 ppM for thallium and bismuth respectively. (auth)

**22045** (CONF-721010-37) COMPARATIVE ANALYSIS OF DIFFERENT COMPUTER HANDLING SYSTEMS FOR GAMMA SPECTROMETRIC DATA DEVELOPED AT C.C.R. ISPRA. Bertozzi, G.; Girardi, F.; Guzzi, G.; Di Cola, G. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1972. 12p. Dep. NTIS (U. S. Sales Only) $3.00.

From International conference on modern trends in activation analysis; Saclay, France (2 Oct 1972).

Three different computer systems for gamma spectrometric data handling were developed. The systems are: batchwise treatment of the data with a large computer, time-shared teleprocessing by means of a centralized computer, and use of a small computer at the laboratory site. Both hardware and software on the three systems are described with emphasis on their practical use and on advantages and disadvantages in routine application. A partial analysis of the running costs of the systems is also presented. (France)

**22046** (CONF-721010-38) QUANTITATIVE EVALUATION OF PHOTON-ACTIVATION METHOD IN ANALYSIS. Kato, T. (Tohoku Univ., Sendai (Japan)). 1972. 10p. Dep. NTIS (U. S. Sales Only) $3.00.

From International conference on modern trends in activation analysis; Saclay, France (2 Oct 1972).

Experimental reaction yields were determined for various types of photonuclear reaction induced in 71 elements by various energy bremsstrahlung irradiations. Lithium-drifted germanium detectors were used. The results obtained led to the evaluation of the different photon activation analysis sensitivities. The reactivities of high energy photons for a wide range of different nuclei are discussed. (France)

**22047** (CONF-721010-39) ACTIVATION ANALYSIS OF MERCURY IN BIOLOGICAL SAMPLES. Kim, J. I.; Sunoko, S. R. (Technische Universitaet, Munich (West Germany). Institut Fuer Radiochemie). 1972. 12p. Dep. NTIS (U. S. Sales Only) $3.00.

From International conference on modern trends in activation analysis; Saclay, France (2 Oct 1972).

A method was developed for the determination of trace quantities of Hg in biological samples. A rotating irradiation disk facility introduced into the reactor pool water is used, and a simple procedure is employed to reduce the possibility of Hg losses during chemical processing. This procedure involves the destruction of the sample in a reflux system with concentrated $HNO_3$ or fuming $HNO_3 + H_2O_2$ and the subsequent separation of the Hg by the spontaneous deposition on copper sieves from dilute $HNO_3$(0.5 to 1.5N). The possibility of using Au or Co as standards instead of volatile Hg is considered. (France)

**22048** (CONF-721010-40) UTILIZATION OF ION EXCHANGERS AND INORGANIC FILTERS FOR THE DETERMINATION OF Se AND Te IN Cu. Mignonsin, E. P.; Guillaume, M. (Liege Univ. (Belgium). Laboratoire d'Application des Radioelements). 1972. 9p. (In French). Dep. NTIS (U. S. Sales Only) $3.00.

From International conference on modern trends in activation analysis; Saclay, France (2 Oct 1972).

When Cu containing Se and Te impurities is irradiated with a beam of thermal neutrons, these impurities produce radioisotopes having considerably longer half-lives than those for Cu. Even after the complete decay of the Cu isotopes a very sensitive nondestructive analysis is not possible owing to the presence of several other radioisotopes. In order to achieve a high sensitivity, the separation of the different isotopes is effected by ion exchange chromatography using a 200 to 400 mesh Dowex I, X-8 resin and the mineral exchanger Pertitanic. Under these conditions, the detection limits are 5 ppB for Te and 0.5 ppB for Se. (France)

**22049** (CONF-721010-42) COMPUTER ANALYSIS OF WEAK SPECTRAL COMPONENTS IN GAMMA-RAY SPECTRA. Yule, H. P. (NUS Corp., Rockville, MD). 1972. 10p.

From International conference on modern trends in activation analysis; Saclay, France (2 Oct 1972).

Optimal accuracy and precision for relatively weak gamma spectral components were the goal of this study. Such components exhibit small photopeaks situated on large Compton continua; an example of this situation often occurs in measurement of low levels of mercury in biological samples. Four calculational methods were tested: peak area, spectrum stripping, least squares, and peak fitting. All the methods were reasonably accurate on the average. The least squares results provided the smallest spread in results, but stripping did almost as well. The other two methods displayed poor precision. The least square technique gave the best results in terms of accuracy, precision, and ease of application. (auth)

**22050** (CONF-721069-8) NONDESTRUCTIVE PHOTON-ACTIVATION ANALYSIS OF STANDARD ROCKS WITH 30 MeV BREMSSTRAHLUNG. Kato, T.; Morita, I.; Sato, N. (Tohoku Univ., Sendai (Japan)). 1972. 10p. Dep. NTIS (U. S. Sales Only).

From International colloquim on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

Photon activation analysis was applied to the nondestructive determination of 16 elements (Na, Mg, Ca, Ti, Cr, Mn, Fe, Co, Ni, Rb, Sr, Y, Zr, Nb, Ba, and Ce) in the U.S.G.S. standard rocks. The rock sample and the multielement standards were irradiated simultaneously with 30 MeV bremsstrahlung radiation. The ($\gamma$, n) and ($\gamma$,p) reaction products were measured with a Ge(Li) detector. (France)

**22051** (CONF-721069-13) APPLICATION OF ACTIVATION ANALYSIS TO THE EARTH SCIENCES. Morrison, G. H. (Cornell Univ., Ithaca, N. Y. Dept. of Chemistry). 1972. 17p.

From International Colloquium on the activation analysis of micro-quantities of elements in very high-purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

The field of activation analysis and its application to the earth sciences are surveyed. These applications are classified according to the technique used and include thermal neutron activation and radiochemical separations for individual nuclides, neutron activation together with gamma spectrometry for multielement analysis, and other methods of activation. Accuracy of activation analysis values for select elements in W-1 is compared, as well as activation analysis and other trace methods in the analysis of a lunar sample. (France)

**22052** (CONF-721069-23) INSTRUMENTAL ACTIVATION ANALYSIS OF ALBUMINS AND NUCLEIC ACIDS. Andronikachvili, E. L.; Mosulichvili, L. M.; Belokobylskii, A. E. 1972. Translated from Russian. 10p. (In French). Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

An instrumental activation analysis method applicable to macromolecules of DNA and RNA and albumins was developed in view of estimating the different contents of various elements (Zn, Fe, Co, Cr, Sb, Ag, Au, and Sc) in albumins extracted from healthy and cancerous organs of experimental animals. (France)

**22053** (CONF-721069-24) DETERMINATION OF O AND N IN ALKALI METALS AND O IN OTHER METALS USING $\gamma$-ACTIVATION ANALYSIS WITH CHEMICAL SEPARATION OF THE SHORT HALF LIFE ISOTOPES. Chapignikov, B. A.; Malikova, E. D.; Kunin, L. L.; Samosyuk, V. N.; Vasserman, A. M.; Frolov, E. V.; Evganov, Kh. N. 1972. Translated from Russian. 17p. (In French). Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

A method of rapidly separating the short half-life isotopes, $^{15}$O and $^{13}$N, from alkali metals and $^{15}$O from other metals (steels, Cu, In) was studied in view of determining O and N by $\gamma$ activation analysis in a $\gamma$ quanta current using a microtron. (France)

**22054** (CONF-721069-27) DETERMINATION OF TRACE ELEMENT IMPURITIES IN NATURAL DIAMONDS BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS. Fesq, H. W.; Bibby, D. M.; Sellschop, J. P. F.; Watterson, J. I. W. (University of The Witwatersrand, Johannesburg (South Africa)). 1972. 12p. Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

The technique of nondestructive neutron activation analysis using high resolution Ge(Li) detectors was applied to the determination of trace impurities in diamonds. The presence of 40 elements in natural diamonds was established. Quantitative results for 13 elements (Fe, Al, Mg, Ti, Cr, V, Sc, Co, Ta, Ce, Eu, Tb, Ba) in 25 representative diamond samples from a single source are presented. (auth)

**22055** (CONF-721069-28) NEUTRON ACTIVATION ANALYSIS OF STEEL FOR SUB ppM AMOUNTS OF LANTHANUM AND GOLD WITHOUT DETERMINING THE CHEMICAL YIELD. Foldzinska, A.; Dybczynski, R. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 11p. Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

A neutron activation analysis method for determining small concentrations (less than 1 ppM) of La and Au in steel, which does not require the evaluation of the chemical yield, is presented. The method consists of quantitatively isolating La and Au using ion exchange techniques and employs NaI(Tl) spectrometry. The lower limits for the detection of La and Au are 10 and 5 ppB respectively. There is almost no interference from other elements present in the steel. (France)

**22056** (CONF-721069-32) ROLE OF ELASTIC SCATTERING ANALYSIS IN STUDIES OF ANODIC OXIDATION. Mackintosh, W. D. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs). 1972. 9p. Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

Elastic scattering analysis is sensitive for microquantities provided that they are concentrated in thin layers. This study has a twofold purpose: the deduction of the relative mobilities of Al and $O_2$ during anodic oxidation from observations of the behavior of inert gas atoms introduced into the samples (immobile markers); the investigation of the movement of certain other foreign atoms during anodic oxidation. (France)

**22057** (CONF-721069-36) ACTIVATION ANALYTICAL METHODS FOR THE GRADING OF SEMICONDUCTOR CRYSTALS. Szabo, E. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). 1972. 13p. Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

The analytical requirements of manufacturing industries are discussed. The results obtained on the bulk, surface, and superficial analysis of semiconductor grade silicon and gallium arsenide are presented. (auth)

**22058** (CONF-721069-37) USE OF PHOTONUCLEAR ACTIVATION REACTIONS AND PHOTONEUTRON-NEUTRON PRODUCTION REACTIONS FOR HIGH SENSITIVITY SYSTEMATIC AND INSTRUMENTAL ACTIVATION ANALYSIS OF ORE AND MINERAL SAMPLES. Sulin, V. V. 1972. Translated from Russian. 13p. (In French). Dep. NTIS (U. S. Sales Only).

From International colloquim on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

Results obtained with polymetallic or ore (W–Mo, alkaline ores, or other types of ore) samples irradiated with bremsstrahlung or photoneutrons (obtained from a betatron, a microtron, or a linear accelerator), indicate that it is possible to identify 21 elements (ranging from F to Pb). Irradiation conditions appropriate to the simultaneous analysis of between 2 and 8 elements with a threshold sensitivity of 0.1 ppM are discussed. (France)

**22059** (CONF-721069-39) DETERMINATION OF IMPURITIES IN VERY PURE Ag USING NEUTRON ACTIVATION WITH SEPARATION OF THE ELEMENTS BY EXTRACTION. Artiukhin, P. I.; Startseva, E. A.; Nikolaev, A. V. 1972. Translated from Russian. 9p. (In French). Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

A neutron activation analysis method for determining 24 micro-impurities in Ag was developed. An extraction was performed to eliminate the matrix and separate the impurities. The screening effect of Ag samples on the neutron flux was evaluated theoretically and experimentally verified. (France)

**22060** (CONF-721069-40) CADMIUM BY IN VIVO NEUTRON ACTIVATION ANALYSIS. Biggin, H. C.; Chen, N. S.; Ettinger, K. V.; Fremlin, J. H.; Morgan, W. D.; Nowotny, R.; Chamberlain, M. J.; Harvey, T. C. (Birmingham Univ. (England)). 1972. 11p. Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

The presence of cadmium may be determined in man using the technique of in vivo neutron activation analysis. Thermal neutron capture of $^{113}$Cd gives rise to a prompt gamma emission which may be detected by suitable semiconductor devices. An installation was built at the University of Birmingham to produce a cyclotron-generated pulsed neutron beam. A series of experiments were carried out on cadavers and phantoms. It was possible to detect cadmium at a concentration of 2.0 ppM in the volume of a human liver for a dose of 1 Rem. The results and possible applications are discussed. (auth)

**22061** (CONF-721069-41) ACCURATE DETERMINATION OF GA IN $Ga_xSe_y$ BY MEANS OF NEUTRON ACTIVATION: A COMPARISON WITH X-RAY FLUORESCENCE AND WET CHEMICAL METHODS. Bruninx, E. (Philips Gloeilampenfabrieken N. V., Eindhoven (Netherlands). Forschungslaboratorium). 1972. 8p. Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

The determination of Ga in Ga–Se was considered. Sample preparation, irradiation, counting methods, and data evaluation are discussed. An overall accuracy of the order of 0.1% was obtained. Systematic errors and various sources of inaccuracy are considered. (auth)

**22062** (CONF-721069-42) APPLICATION OF INORGANIC EXCHANGERS TO RADIOCHEMICAL SEPARATIONS ON NEUTRON ACTIVATED HIGH PURITY MATERIALS. Cuypers, J.; Girardi, F.; Mousty, F. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1972. 12p. Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

The application of inorganic exchangers to the destructive analysis of high purity materials, particularly for the systematic determination of many elements, is studied. Recent improvements in the methodology for the mathematical assessment of radiochemical separation schemes by means of inorganic exchangers are briefly outlined. Separation schemes for the determination of impurities in high-purity aluminium and zinc are presented. Results are given for several zinc samples obtained by successive purifications, showing variation trends for the distribution of various impurities. Results obtained in the application to a zinc sample used as standard reference material are also presented. (auth)

**22063** (CONF-721069-44) ACTIVATION ANALYSIS OF MICROQUANTITIES OF ELEMENTS IN BIOLOGICAL MATERIALS. Kist, A. A.; Khatomov, Ch.; Krygenkova, N. A.; Orestova, S. S.; Tuchkova, R. Ya.; Juk, L. I.; Flitsian, E. S.; Gofen, G. I.; Tchekhomova, L. A.; Danilova, E. A.; Abdullaev, Ya. S.; Batygina, N. A. 1972. Translated from Russian. 11p. (In French). Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of microquantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

Examples are given of the use of activation analysis in biogeochemical investigations of Au, the differential analysis of eye tissues, the determination of residual quantities of pesticides, and the investigation of minor modifications in the concentration of microquantities of elements in studies with prior mineralization of the substances under investigation. The accuracy of the analysis is estimated. (France)

**22064** (CONF-721069-46) INVESTIGATIONS OF THE CORROSIVE DEPOSITION OF COMPONENTS OF METAL IMPLANTS AND OF THE BEHAVIOUR OF BIOLOGICAL TRACE ELEMENTS IN METALLOSIS TISSUE BY MEANS OF INSTRUMENTAL MULTI-ELEMENT ACTIVATION ANALYSIS. Lux, F.; Zeisler, R. (Technische Universitaet, Munich (West Germany). Institut fuer Radiochemie). 1972. 9p. Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

The behavior of the following elements in metallosis tissue was investigated using activation analysis: the components of V4A-steel (Fe, Cr, Ni, Mo); Ag, and Ta occurring as pure metal implants; and Co, Zn, and Sb (biological trace elements). Radiochemical techniques were used to separate $^{24}$Na in the case of the determination of Mn. The detection limits lie between 0.005 ppM (Ta) and 5 ppM (Fe). The results of the analysis indicate that an intercellular transcrystalline corrosion of the implant material followed by a rapid removal of the single components occurs. Iron is stored as a slowly degrading biological compounds. The content of the essential trace element, Zn, in metallosis tissue is considerably decreased. This may be due to the displacement of enzyme bonded Zn by the implant components which leads to changes in the enzyme processes governing the metallosis behavior. (auth)

**22065** (CONF-721069-47) NEUTRON ACTIVATION ANALYSIS OF PURE Se. Application of Resin Ion Exchange Chromatography to the Systematic Analysis of Se. Mignonsin, E. P. (Liege Univ. (Belgium). Laboratoire d'Application des Radioelements). 1972. 6p. (In French). Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

Chromatographic separation with ion exchange resins is proposed for analyzing impurities in Se. After dissolution in a nitric–hydrofluoric acid mixture, the method enables the separation to be accomplished using I–X–8 Dowex resins (200 to 400 mesh) in three large radioisotope groups each consisting of 12 to 14 elements. The separations are carried out with different eluants for each group. (France)

**22066** (CONF-721069-48) DETERMINATION OF O, N, AND C IMPURITIES IN PURE MATERIALS USING FAST NEUTRON AND $\gamma$-RAY ACTIVATION ANALYSIS. Pronman, I. M.; Andreev, A. V.; Karpov, Yu. A.; Kudinov, B. S. 1972. Translated from Russian. 12p. (In French). Dep. NTIS (U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

Neutron and $\gamma$ ray activation methods used to determine O, N, and C are presented. An attempt was made to avoid effects due to surface contamination and to efficiently separate the $^{15}$O, $^{13}$N, and $^{11}$C isotopes. (France)

**22067** (FRNC-CONF-79) AUTOMATION OF AN ANALYSIS SCHEME FOR HIGH PURITY Fe. Cleyrergue, C.; Deschamps, N. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1972. 10p. (In French). (CONF-721069-25). Dep. NTIS ( U. S. Sales Only).

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

Neutron activation analysis can be used to determine impurities (As, Sb, Mo, W, Ga, Sc, Zr, Cu, Au, Ag, Cr, Zn, Co, Mn, and Na) at concentrations of the order of $10^{-8}$ g/g in 100 mg Fe samples. In order to make these determinations, the fixing of Fe with Sn oxide was studied as a function of temperature and acid concentration. Some of the chemical operations were automated in order to reduce the handling of highly radioactive products. (France)

**22068** (IRI-133-71-3) COMPUTER ORIENTED SYSTEM FOR NON-DESTRUCTIVE NEUTRON ACTIVATION ANALYSIS. de Bruin, M.; Korthoven, P. J. M. (Interuniversitair Reactor Instituut, Delft (Netherlands)). 1972. 12p. (CONF-710623-2). Dep. NTIS (U. S. Sales Only).

From second conference on the recent developments in neutron activation analysis; Cambridge, UK (28 Jun 1971).

A system consisting of a gamma spectrometer directly coupled to a PDP-9 computer is described. The computer is used during data collection and for the fully automated spectrum analysis and interpretation. With the aid of a pneumatic sample changer, low as well as high activity samples can be handled. Therefore only one neutron irradiation is sufficient for measurements of isotopes with both short and long half lives. The application of the single comparator method considerably reduces the time needed for standard preparation. (auth)

**22069** (LBL-682) $^3$He ACTIVATION ANALYSIS FOR S, Cl, K, and Ca. Lee, D. M.; Markowitz, S. S. (California Univ., Berkeley. Lawrence Berkeley Lab). 1971. 9p. (CONF-721069-45). Dep. NTIS.

From International colloquium on the activation analysis of micro-quantities of elements in very high purity inorganic and organic substances and in biological media; Saclay, France (2 Oct 1972).

Three easily detected radionuclides, $^{38}$Cl, $^{34m}$Cl, and $^{38}$K, produced from the interactions of sulfur, chlorine, potassium, and calcium, were used for the determination of the latter elements by $^3$He activation analysis. A number of samples were analyzed nondestructively using different nuclear reactions to examine the accuracy of the method and the extent of interferences. Absolute excitation functions for the $^3$He reactions are given. (auth)

**22070** (STI/PUB-310) NUCLEAR ACTIVATION TECHNIQUES IN THE LIFE SCIENCE, 1972. Proceedings Series. Proceedings of a Symposium Held in Bled, Yugoslavia, April 10-14, 1972. (International Atomic Energy Agency, Vienna (Austria)). Nov 1972. 672p. (In several languages). (CONF-720425-). IAEA $23.00.

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972).

Separate abstracts were prepared for 48 of the 49 papers presented. The remaining paper, on the use of the stable tracers $^{58}$Fe and $^{50}$Cr for the study of iron utilization in pregnant women, appeared in volume 26 of NSA as abstract number 19916. (ERB)

*For abstracts of individual papers see: 22041, 22076–22116, 22535, 22620, 22798, and 22817–22819.*

**22071** DETERMINATION OF MICROIMPURITIES IN QUARTZ SAMPLES BY THE RADIOACTIVATION METHOD OF ANALYSIS. Razeghi, M.; Parsa, B. (Teheran Univ.). Radiochem. Radioanal. Lett.; 13: No. 2, 95-100(5 Mar 1973).

Seventeen elements at trace levels were determined by neutron activation analysis in a quartz sample. Na, K, Sc, Mn, Fe, Co, Zr, Nb, Sb, Cs, La, Eu, Yb, Hf, Ta, Au, and Th were determined by a nondestructive technique using a high resolution Ge(Li) detector. (auth)

**22072** SIMPLE METHOD OF NEUTRON-FLUX NORMALISATION FOR LARGE SIZED SAMPLES: DETERMINATION OF PARTS PER BILLION LEVELS OF COPPER IN DISTILLED WATER BY NEUTRON ACTIVATION ANALYSIS. Desai, H. B.; Iyer, K. R. (Bhabha Atomic Research Centre, Trombay, India). Radiochem. Radioanal. Lett.; 13: No. 2, 75-81(5 Mar 1973).

When a large size sample needs to be irradiated for the estimation of trace elements by neutron activation analysis, spatial variation of flux becomes significant. A method of flux normalization by the use of a suitable standard sample configuration during irradiation is presented. The method was applied to the determination of copper at 1 in $10^9$ levels in distilled water. (auth)

**22073** FAST RADIOCHEMICAL SEPARATION OF RARE EARTHS FROM ROCK SAMPLES BY RETENTION ON LANTHANUM OXALATE. Csajka, M. (Central Research Inst. for Physics, Budapest). Radiochem. Radioanal. Lett.; 13: No. 2, 151-159(5 Mar 1973).

Rare earth activities were retained to 98 to 99% in less than 1 minute on lanthanum oxalate and selectively separated from irradiated samples. The method was tested in the activation analysis of USGS W1-type standard rock and results showing the usefulness, accuracy, and reproducibility of the procedure are presented. (auth)

**22074** QUANTITATIVE ANALYSIS OF THIN-LAYER CHROMATOGRAMS WITH LOW $^{14}$C-ACTIVITIES BY SILVER ACTIVATION AND MERCURY LABELING OF THE AUTO-RADIOGRAMS. Haikal, I. (Oesterreichische Hochschule, Vienna); Bobleter, O. J. Chromatogr.; 76: No. 1, 191-197 (7 Feb 1973). (In German).

The concentration of $^{14}$C-labeled sugars (glucose, fructose, and xylose) on thin-layer chromatograms was determined with autoradiograms (contact method; eight days' exposure). Since photodensitometric measurements did not give the precision required, the silver content of the radiograms was determined directly by neutron activation analysis. This method reduces error and facilitates the analytical procedure but requires a long decay time. The precision of the measurements was increased by application of a mercury multiplication solution ($^{203}$Hg-labeled) on the autoradiograms. The mercury activity can be determined immediately after exposure. The graph obtained by plotting the logarithm of the concentration against the mercury activity has a linear region from $10^{-4}$ to $10^{-2}$ $\mu$Ci. (auth)

**22075** NEUTRON-ACTIVATION ESTIMATION OF THE DISTRIBUTION OF IMPURITY IN THIN SILICON LAYERS. Perezhogin, G. A. Zh. Anal. Khim.; 27: No. 11, 2222-2226(Nov 1972). (In Russian).

The neutron activation estimation of the profile of the distribution of an impurity in multilayer silicon structures includes the successive removal of the silicon layers, using hydrofluoric and nitric acids, and the determination of the impurity in each layer. The thickness of a layer removed is determined by the activity of a silicon isotope. The accuracy and sensitivity of the determination of the layer thickness depends on the impurity concentration, nuclear characteristics of the silicon, and impurity isotopes as well as on the activation and cooling duration. The distribution of an impurity in thin layers of silicon oxide and silicon nitride can be estimated. (auth)

**22076** ELEMENTS NEWLY IDENTIFIED AS ESSENTIAL FOR ANIMALS. Schwarz, K. (Veterans Administration Hospital, Long Beach, CA). pp 3-22 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425-.

In contrast to the 11 elements of low atomic weight that constitute the bulk of living matter, essential trace elements are effective in very small amounts. They are always linked to organic compounds by coordination or covalent bonds. The principal parameters and dimensions that characterize the role of trace elements in health and disease processes are illustrated, using as examples some elements recently discovered to be indispensable. Determination of an element in diets, tissues, or blood does not constitute an estimate of biological activity. To determine availability, nutritional balance studies and biological assays are needed. Trace elements, aside from their toxicological effects, play a major role in disease mechanisms if there is too little, too much (imbalance), or if there are disturbances in their utilization and metabolism. Areas where trace-element function may be implicated etiologically are atherosclerosis, cerebral arterial disease, cancer, cardiomyopathy, muscular dystrophy, and some degenerative diseases of the central nervous system, and possibly even some diseases as common as degenerative osteoarthritis. For many of the problems in bioinorganic chemistry and clinical trace-element research, activation analysis appears to be the optimal approach. (MCG)

**22077** TRACE-ELEMENT ANALYSIS AND ELECTROCHEMICAL STUDIES OF MICROQUANTITIES OF BIOLOGICAL SAMPLES BY PROMPT ATOMIC AND NUCLEAR REACTIONS. Demortier, G. F. A.; Gillet, C.; Lefebvre, J. (Facultes Univ., Namur, Belg.). pp 23-38 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

Ion exchange in biological samples is usually studied by the radioactive tracer method. A method of measuring the electrochemical properties of biological ion exchangers, using prompt atomic and nuclear reactions, is proposed. Using protons in the MeV range and measuring the yields of prompt emitted x and $\gamma$ rays with cooled Ge(Li) and Si(Li) detectors, it is now possible to perform quantitative analysis of each element from F to U in high concentration or at trace level in microquantities of biological material (a few micrograms). The description of the experimental set-up used is presented. Special studies on dry walls of nitella (alga) are described within the scope of the ion-exchange process, the measurement of the variations of the osmotic pressure and the trace analysis of medium and heavy elements. Perspectives of the electrochemical studies to be performed by this method and the sensitivities of trace analysis are explained. The principal advantages of this method are: rapidity, absence of residual activity, need of very small quantities of material for a single analysis, and reduced handling before the measurements. The progressive destruction of the sample during the proton bombardment may be controlled and taken into account for quantitative analysis (auth)

**22078** USE OF GAMMA ACTIVATION TO STUDY THE BEHAVIOUR OF CERTAIN METALS, IN PARTICULAR LEAD, DURING THE DRY ASHING OF BONE. Hislop, J. S.; Williams, D. R. (Atomic Energy Research Establishment, Harwell, Eng.). pp 51-62 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

Nondestructive $\gamma$ activation analysis was used to determine the concentration of lead in human rib. Subsequent nondestructive measurements of the lead content of the sample after ashing successively at temperatures in the range 420 to 710°C have volatility and retention losses to be evaluated. Analysis is based on the measurement of the 279-keV radiation of $^{203}$Pb using high resolution $\gamma$ spectrometry. Interferences derived from the matrix and from other trace elements are discussed. Volatility and retention losses of calcium, sodium, and potassium on ashing human rib were also studied. The results obtained by nondestructive $\gamma$ activation are compared with (a) the behaviour during ashing of $^{203}$Pb, present as carbonate and phosphate, intimately mixed with dried rib and also in the absence of the matrix, and (b) where applicable, results obtained by other analytical methods. (auth)

**22079** NEUTRON RESONANCE METHODS OF ELEMENTAL ANALYSIS. Gambaryan, R. G. (All-Union Scientific Research Inst. of Radiation Tech., Moscow). pp 63-70 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Three methods of analysis based on the use of resonance neutrons are reviewed: activation analysis, absorption analysis, and capture gamma analysis. The use of resonance neutrons considerably increases the selectivity of the analysis. All three methods appear to have considerable potential for further development. At the present time the most promising technique, especially for trace elements in biological materials, appears to be resonance neutron activation analysis with reactor neutrons. (auth)

**22080** MULTI-ELEMENT DETERMINATION IN BIOLOGICAL TISSUES BY NEUTRON ACTIVATION ANALYSIS AND SEMICONDUCTOR GAMMA SPECTROSCOPY. Plantin, L. O. (King Gustaf Vth Research Inst., Stockholm). pp 73-88 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

Samples of blood or other biological tissues weighing from 0.5–1.0 g were dried in quartz ampoules and irradiated for about 7 d (170 h) at a flux of $2 \times 10^{13}$ n cm$^{-2}$ s$^{-1}$ together with multielement standards. After a cooling period of two days the samples were dissolved in an acid mixture under reflux. The solution of the sample in 11 M HCl was then passed through a column of hydrated antimony pentoxide (HAP), which was washed with more 11 M HCl. The eluate went directly on to a Dowex 1 × 8 column. After passage through the ion exchanger the eluate was evaporated to dryness, dissolved in 0.1 M HCl, and the solution applied to a column of Dowex 50. This column was washed with 0.1 M HCl. The Dowex 1 column was further washed first with 0.5 M HCl and then with 0.01 M HCl. The trace elements were separated into six fractions that were counted on a Ge(Li) detector with a 24-cm$^3$ active volume and a resolution of about 3.5 keV. The gamma spectrum was recorded by a multichannel analyser in 2000 channels and punched on paper tape. The tape was used to transfer the gamma spectrum to an IBM 360/75 computer for evaluation. This was done with an ALGOL program called PEAKAREA, which smoothed the spectrum, localized the photopeaks, calculated their area, and identified the nuclides present. The peak-areas were then compared with the corresponding peaks in the multielement standards and the concentration of the trace elements in the sample calculated in ppM and printed. A picture of the smoothed gamma spectrum was also obtained. On every peak the count-rate and the energy were indicated. The following trace elements were more or less regularly found in human tissues: Ag, As, Au, Ba, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Hg, La, Mo, Rb, Sb, Sc, Se, Sm, Sr, and Zn. (auth)

**22081** VANADIUM DETERMINATION IN BIOLOGICAL MATERIALS BY THE USE OF PRECONCENTRATION. Levstek, M.; Kosta, L.; Dermelj, M.; Byrne, A. R. (Josef Stefan Nuclear Inst., Ljubljana, Yugoslavia). pp 111-117 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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The complex nature of biological samples, the short half-life of $^{52}$V, and the low concentration in which it occurs in such materials ($10^{-6}-10^{-9}$ g/g) makes its direct determination by neutron activation and gamma spectrometry practically impossible. To achieve high sensitivity, a rapid post-irradiation separation is necessary. Some kind of pretreatment is therefore usual, such as ashing or a preconcentration stage. Pre-ashing makes sensitive analysis feasible by using fast separation techniques, but its applicability is doubtful owing to possible volatilization losses. In this investigation the determination is based on a preliminary combustion of the sample in oxygen in a closed system followed by coprecipitation on hydrolysed bismuth oxynitrate. The filtered precipitate is irradiated, dissolved in hydrochloric acid, and vanadium extracted into benzene using N-benzoylphenylhydroxylamine as reagent. An aliquot of the organic phase is counted in a sodium iodide detector and gamma spectrometer. Post-irradiation separation time is 5 min. A difference spectrum is obtained by recounting after a short interval in the subtract mode. Yield determinations are based on $^{48}$V tracer added to the sample before ignition. The differential spectra obtained are clean and allow precise determination of vanadium with practical limits in the range of a few nanograms. Accuracy is mainly limited by the reagent blank introduced in the preseparation stage, which at present is about 10 ng for the complete procedure. Results have been obtained for the standard materials Bowen's kale and NBS orchard leaves, as well as other samples. Comparative results on ashed samples and those from the proposed method show that losses of vanadium during ashing can be very substantial. (auth)

**22082** DETERMINATION OF VANADIUM IN BIOLOGICAL MATERIALS BY NEUTRON ACTIVATION ANALYSIS. Damsgaard, E.; Heydorn, K.; Rietz, B. (Danish Atomic Energy Commission, Risoe). pp 119-128 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna, International Atomic Energy Agency (1972).

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The low levels of vanadium in soft tissue necessitate analytical methods of high sensitivity for accurate determination, and neutron activation analysis appears very attractive in this respect. A pre-irradiation separation of vanadium followed by instrumental neutron activation analysis was used in a number of cases. The separation procedure consists in dry ashing the sample in a quartz crucible followed by extraction of vanadium with 8-hydroxy-quinoline or 8-hydroxy-quinaldine in chloroform from a nitric acid solution, using aluminon to retain aluminum. After evaporation of the chloroform, the vanadium complex is dissolved in pyridine and irradiated for 2 min at $7 \times 10^{12}$ n cm$^{-2}$ s$^{-1}$. The irradiated sample is transferred to a counting vial and counted for 1 min at 3 and 10.5 min decay time. The difference spectrum is used for the estimation of vanadium by means of a comparator of the same material containing a known amount of added vanadium and treated in exactly the same way as the sample. Recoveries of vanadium were determined by added natural vanadium as well as by a $^{48}$V tracer. Blank values were about 0.55 $\mu$g with a standard deviation of 0.001 $\mu$g, and the critical reagent was nitric acid, the quantity of which must be kept within narrow limits. Results of vanadium determinations in biological material, including kale and orchard leaves, are presented. The precision of the method was improved from 10 to 12% to about 4% by the addition of tracer to all samples analyzed, and the use of about 0.03 $\mu$Ci of $^{48}$V did not significantly increase the limit of detection. (auth)

**22083** DETERMINATION OF LEAD IN BIOLOGICAL MATERIALS BY NEUTRON ACTIVATION ANALYSIS. Gibbons, D.; Perkins, M.; Sanders, T. W. (United Kingdom Atomic Energy Establishment, Harwell, Eng.). pp 131-138 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Lead is not usually considered an appropriate element for measurement by neutron activation analysis. Nevertheless, there are occasions when an independent method of analysis is required, or when some interference peculiar to more conventional methods must be overcome. A reasonably rapid method for the radiochemical purification of 3.3 h $^{209}$Pb, based on extraction of a lead bromide complex with methyl tricapryl ammonium chloride (Aliquat 336) together with appropriate scavenging steps, was tested on a variety of biological samples including Biological Reference Materials, and the sensitivity and limitations of the technique under practical conditions were evaluated. The results are compared with those obtained by other methods of analysis, including gamma photon activation, spectrographic, and absorptiometric techniques. (auth)

**22084** EXPERIMENTAL COMPARISON BETWEEN NEUTRON ACTIVATION ANALYSIS AND OSCILLOGRAPHIC POLAROGRAPHY WITH A DOUBLE ELECTROLYTIC CELL IN DETERMINING TRACE ELEMENTS IN AQUATIC PLANT SAMPLES. Bagliano, G.; Chamard, P.; Clemente, G. F. (CNEN, Rome). pp 139-154 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Polarography and activation analysis are among the most sensitive techniques for determining trace elements. An experimental comparison between these techniques when applied for the determination of oligoelements in the same aquatic plant samples is presented. Any chemical separation of the elements of interest is avoided by using a suitable method for each technique. The concentrations of Fe, Co, Ni, Cu, Zn, and Pb were determined by oscillographic polarography with a double electrolytic cell on the same 1M $HNO_3$ solution, obtained by dissolving 100 mg ashed sample. The concentrations of Sc, Cr, Fe, Co, Zn, As, Br, Rb, Sb, Cs, La, Eu, and Th, were determined by neutron activation analysis on ashed samples, which were irradiated with an integral flux of $225 \times 10^{16}$ neutrons/cm$^2$. The radioactivity induced in the samples was measured at different times after the activation, selected depending upon the physical half-life of the different radionuclides. The measurements were performed by using a 32-cm$^3$ and a 56-cm$^3$ Ge(Li) detector. The detectors are equipped with a 4096-channel analyser connected on-line to a DEC-PDP 8/L computer. The sensitivity and precision of the two analytical methods are reported for all the elements measured. The loss due to dry ashing at 450°C was evaluated by measuring the same sample before and after ashing. The good agreement between the results obtained with the two different techniques confirms that the analytical procedures followed in both cases were reliable. (auth)

**22085** RELIABILITY OF NEUTRON ACTIVATION ANALYSIS FOR TRACE ELEMENTS IN BIOLOGICAL MATERIALS. Heinonen, J.; Suschny, O. (International Atomic Energy Agency, Vienna). pp 155-173 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425-.

In connection with the general Analytical Quality Control Services, the IAEA has organized in recent years a series of intercomparisons for the determination of some trace elements in biological materials by neutron activation techniques. Four of the intercomparisons dealt with analyses of pesticide residues, i.e., determination of bromine and mercury in flour. The concentration to be assayed varied from the parts per billion ($10^9$) range in the case of background concentration to the parts per million range in the case of contaminated material. The results show that the reliability of data in the ppM range seems satisfactory both from the aspect of monitoring and of research, but is unsatisfactory in the ppB range, especially for scientific purposes. In cooperation with a number of institutes, three further intercomparisons were organized in biological trace analysis by neutron activation techniques. This study involved the determination of six trace elements: iron, copper, manganese, zinc, chromium, and molybdenum at background levels in animal blood, animal bone, and mussel shell. They served the needs of many laboratories working on biological and medical problems. Unfortunately the number of participating institutes was not sufficiently large to permit an evaluation of the different methods used. The graphical compilation of data gives a general idea of the scattering of the results. Most results show a consistent picture. It is evident, however, that some laboratories are not in the position to state the reliability of their results which are often strongly biased, which clearly demonstrates the need for a comprehensive and regular Analytical Quality Control Service, especially in trace analysis. (auth)

**22086** MERCURY HAZARDS IN DENTAL PRACTICE: ASSESSMENT AND CONTROL BY ACTIVATION ANALYSIS. Lenihan, J. M. A. (Western Regional Hospital Board, Glasgow); Smith, H.; Harvey, W. pp 195-212 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Results are presented from a large survey of personal and environmental contamination from mercury in dental practice in the city of Glasgow. Mercury was estimated by thermal neutron activation analysis (with post-irradiation chemical separation) in samples of (a) head hair, (b) pubic hair, (c) fingernail, and (d) toenail from 154 dental workers, practitioners, nurses, and surgery assistants (all engaged in work with mercury amalgam) and clerical and workshop staff (not exposed to mercury). Elevated mercury levels, sometimes several hundred times above normal, were found in virtually all the workers involved in the preparation, insertion, or removal of amalgam fillings. Mercury levels in head hair and fingernails are influenced largely by environmental contamination (vapor or aerosol); levels in pubic hair and toenail are determined by mercury ingested and metabolized. Mercury levels in the various groups of workers are correlated with workload, handling techniques, and environmental conditions (such as mercury vapor and aerosol levels) in the surgery. Preliminary suggestions are made towards a code of conduct for the better control of mercury hazards in dental practice. (auth)

**22087** NEUTRON ACTIVATION ANALYSIS AS A DIAGNOSTIC TOOL FOR DETECTING LUNG DISEASE INITIATED BY HARD-METAL DUST. Brune, D. (Atkiebolaget Atomenergi, Studsvik, Sweden); Bivered, B.; Mattsson, S.; Zetterstroem, O. pp 213-218 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425-.

Neutron activation analysis of cobalt, tantalum, and tungsten present in lymph node tissues from the lung was performed on normal and diseased tissues in an attempt to find a correlation between suspected cases of pneumoconiosis and the inhalation of hard-metal dust. The metals searched for in the tissues are common components of hard-metal alloys. In the instance of the diseased tissues, a high tungsten content was observed. In the normal individuals, tungsten was not observed. The neutron activation analysis procedure was carried out instrumentally. The technique may find application in diagnosis to detect the presence in various organs of injurious material introduced by dust inhalation. (auth)

**22088** NEUTRON ACTIVATION ANALYSIS OF BLOOD AND BODY TISSUE FROM RATS EXPOSED TO WELDING FUME. Hewitt, P. J.; Hicks, R. (Univ. of Bradford, Eng.). pp 219-232 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425-.

Several authors have reported a high incidence of respiratory complaints amongst workers exposed to fumes produced during electric arc welding. These fumes contain a variety of potential hazardous materials, including fluorides, silica, and finely divided metallic oxides, in a respirable form. The health hazard of weld fume metals, other than iron which is known to be present in high concentration of welders' lung, has not been systematically studied. Although some of the metals are present in the welding fume at very low concentration, they may act synergistically. Techniques based on instrumental (Ge/Li) neutron activation have the required sensitivity, and lower detection limits to permit a detailed investigation of the distribution of weld fume metals in animal organs. Studies of a group of welders occupationally exposed, and of rats exposed to weld fume in high concentration are described. The objective of the first experiments was to gain information on the short-term physiological and histopathological effects of gross exposure to fume, and the accumulation of unusual metallic concentrations in rat organs. Male albino rats (CSE strain) were exposed in a specially constructed chamber. The fume was analyzed for a series of metals and the particle-size distribution determined by electron microscopy. Immediately post exposure and thereafter at selected time intervals up to three months, exposed rats and unexposed controls were killed. Freeze-dried samples of blood, liver, kidney, and lung were analyzed by instrumental neutron activation using an 80-cm$^3$ lithium drifted germanium detector on line to a multichannel analyzer and computer. Elevated levels of several metals from the weld fume were found in some of the exposed organs and the elimination half time for lung has been measured. The results of histopathological examination are reported. Parallel with these studies of the rat and, in order to obtain long-term human data, a group of welders occupationally exposed to fume have been clinically examined and their working environments monitored. The preliminary results of neutron activation analysis of blood and other samples are reported. (auth)

**22089** NEUTRON ACTIVATION ANALYSIS OF SMOKE RELEASED DURING THE PRODUCTION OF NODULAR CAST IRON, AND THE DETERMINATION OF POSSIBLE EFFECTS ON MAN. Dams, R. F. J.; Temmerman, G.; Vanhoorne, M. (Univ., Ghent). pp 233-250 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

Neutron activation analysis using Ge(Li) gamma spectrometry and computer-assisted data reduction, already used for studying environmental air pollution, was extended to study intense but short-time indoor aerosol emissions. The sensitivity and selectivity of this technique permit the analysis of very short-period samples from locations with elevated concentrations, as in the neighborhood of strong sources. Results of one such source study, initiated in response to complaints of foundry workers about the smoke released by the trigger process during the production of nodular cast iron, are reported. Air-filter samples of a few minutes' duration were taken close to and at a distance from the reaction vessel before, during, and after the trigger process. Mass distributions over particle size were sampled with an eight-stage cascade impactor equipped with a final filter. More than 30 elements were determined on each of the filters and impactor stages. Concentrations of several elements were found to be more than 1000 times higher than in outdoor urban air. A number of elements also displayed pronounced concentration increases during the trigger process. After the triggerings some of these rapidly decreased in concentration, while others decreased only after the entire production had ceased. A detailed investigation of the concentration levels and variations during the day made it possible to determine which elements were strongly emitted during the different steps of the production process. Comparison of the concentrations with threshold limit values revealed that some safety limits were temporarily exceeded. Relatively volatile elements were found to be associated with small particles, and can thus be inhaled deeply. While these evaluations sufficed for an estimation of potential health hazards, a medical examination of the workers showed a decrease of vital capacity shortly after exposure to the smoke. Metal fume fever was not found. Long-term effects on man are as yet unknown. These results demonstrate the applicability of aerosol sampling and neutron activation analysis to health problems associated with short-time indoor smoke production. (auth)

**22090** ENVIRONMENTAL POLLUTION: USE OF NEUTRON ACTIVATION ANALYSIS TO DETERMINE THE FATE OF TRACE ELEMENTS FROM FOSSIL FUEL COMBUSTION IN THE ECOLOGICAL CYCLE. Lyon, W. S.; Bate, L. C.; Emery, J. F. (Oak Ridge National Lab., TN). pp 253-262 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

More than 500 million tons of coal were burned in the United States of America in 1970. Although we have some idea of the total $SO_2$ and particulate matter emitted by the stacks from a few plants, virtually nothing is known about the fate of the many inorganic constituents of coal. Mercury, cadmium, arsenic, and zinc for example are known to be quite toxic, and large quantities of these elements are obviously deposited somewhere. Therefore a program has begun at ORNL to study the trace-element profile through a coal-fired steam plant. In cooperation with the Tennessee Valley Authority (TVA) coal and air entering a TVA steam plant have been sampled, and also all the wastes and emissions from the combustion of the coal. Thus samples of slag, various precipitors in the gas stream pathway, and finally the exhaust gas of the steam plant have been obtained. These samples are being analysed by neutron activation analysis (NAA) both nondestructively and by dissolution and chemical separation of certain elements. In addition, some samples have been analysed by spark source mass spectrometry (SSM) and these results compared with those from NAA. Flameless atomic absorption has been used to determine mercury in many of these samples and comparison with NAA indicates excellent agreement; this latter point is further substantiated by results obtained from determination of Hg in a series of US Bureau of Mines round-robin coal samples. The data from these studies have importance in the overall study of trace elements in all living systems since most of the effluent material from these steam plants finds its way back to the ecological cycle through one path or another. Neutron activation analysis thus provides important information in assisting governmental agencies to plan for proper control and disposal of such waste materials. (auth)

**22091** AIR-POLLUTION STUDY OF GUILDFORD, SURREY, USING NEUTRON ACTIVATION ANALYSIS. Hasan, O.; Spyrou, N. M. (Univ. of Surrey, Guildford, Eng.). pp 263-276 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Neutron activation was used to analyze air-borne particulates collected on cellulose filters. Air-sampling at ten sites in the Guildford area was carried out during the summer of 1971. The city's Public Health Department made available samples collected at two stations over the past five years. Sampling times varied from two hours to four days. Irradiations and gamma spectra observations on a 30-cm$^3$ Ge(Li) detector were carried out at the University of London Reactor Centre. Although several irradiation times were used only the results from 5-min irradiations are presented here. Twenty elements were detected in the samples and Na, Al, Cl, V, Mn, Br and In were determined. The variations of elemental concentrations during August (1967 to 1971) present a time distribution. For comparison, results from sampling during a winter month are also shown. V and Al concentrations were found to be very high. (auth)

**22092** ACTIVATION ANALYSIS OF CONTAMINATING DUST IN THE AIR OF MEXICO CITY. Navarrete, M.; Galvez, L.; Tzontlimatzin, E.; Ley, A. (Centro Nuclear de Mexico, Mexico City). pp 277-286 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972). (In Spanish).

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Since Mexico City represents one of the most serious cases of atmospheric contamination by dust, the Nuclear Laboratory of the University of Mexico and the National Nuclear Energy Commission have undertaken a joint activation analysis study of this contaminant, making use of the Triga Mark III reactor (1 MW(th)). It is intended that this study form a part of the national program for the control of contamination, by obtaining data that may be doubly useful: first, to determine elements that, despite their low concentrations, may be harmful to public health; second, to find tracers that will be of use in localizing important sources of contamination and in determining their mechanisms and degree of diffusion. The activation analysis work was started in the winter of 1971, with sample taking at 24-h periods at a point in the southern-most part of the city, where the University is located. For this purpose an air-sampling pump with a Dexter filter paper (grade C-1140) was used, which has demonstrated a reasonable degree of transparency for thermal neutrons. This first stage of the work was qualitative in character, the samples having been irradiated for periods of 1 min, 1 h and 6 to 60 h with intervals of 12 h of decay for every 6 h of irradiation. The gamma spectra were taken with a Ge(Li) detector connected to multichannel analyzers (400 and 1024 channels) calibrated in scales from 0 to 2 MeV and 0 to 4 MeV. The elements present were identified on the basis of radiation energy, half-life and, in cases of doubt, by radiochemical separation of the presumed radioisotope. In this way it was possible to identify Na, K, Br, Cl, V, Mn, Al, Ca, and As. It is intended to have samples taken during all the seasons of the year at the four cardinal points and in the centre of the city and then to determine the relative content in air of the elements found. (auth)

**22093** NEUTRON ACTIVATION ANALYSIS OF THE AQUATIC ENVIRONMENT IN THE SAVA RIVER. Draskovic, R.; Radosavljevic, R.; Tasovac, T.; Zaric, M. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). pp 287-293 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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As a part of an interdisciplinary program for studying physical, chemical, biotic, and biogeochemical processes in the fresh waters of Yugoslavia, especially in rivers and lakes, determinations of trace-element concentrations (Cr, Sb, Sc, Fe, Co, Na, and La) and concentration factors in different components of the Sava River aquatic system were made by nondestructive neutron activation analysis (Ge-Li detector). The results of these investigations show existing regularities and are of practical and theoretical importance for understanding the complex behavior of trace elements in the aquatic systems. (auth)

**22094** MERCURY DISTRIBUTION LEVELS OBSERVED IN VARIOUS ECOSYSTEMS AS DETERMINED BY NEUTRON ACTIVATION ANALYSIS. de Goey, J. J. M. (Interuniversity Reactor Inst., Delft, Netherlands); Houtman, J. P. W.; Tjioe, P. S.; Koeman, J. H. pp 295-307 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Since 1967, neutron activation analysis has been extensively applied in the Netherlands for investigating the distribution of mercury in water, plants, fish, birds, tissues of mammals, biological fluids, foodstuffs, industrial products, and pharmaceuticals. For this purpose an automated instrument was devised for measurement of mercury concentration above 0.1 ppB in 90 samples per week. Some information is provided about the transport of mercury from soil (river sludge) via grass to cattle, about the behaviour of mercury in the ecosystems water, molluscs, eider-duck; water, fish, sandwich tern; water, fish, seal, and about the uptake of mercury from organic seed dressings (through mice) by predatory birds. Finally, mercury contents of various canned fish samples for human consumption are given. (auth)

**22095** DETERMINATION OF CADMIUM AND MERCURY IN BIOLOGICAL SAMPLES AND TAP WATER. Das, H. A.; Van Der Sloot, H. A. (Reaktor Centrum Nederland, Petten). pp 309-320 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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The determination of cadmium in biological samples is performed by neutron activation analysis, using liquid–liquid extraction for the chemical isolation. Mercury can often be determined by neutron activation in a purely instrumental way. If necessary, chemical isolation is performed in a closed or an open system. For tap water, isotope dilution using (relatively) short-lived radionuclides is used. (auth)

**22096** ESTIMATE OF TRACE ELEMENTS IN CATTLE-LIVER BIOPSY SAMPLES BY NONDESTRUCTIVE ACTIVATION ANALYSIS WITH A Ge(Li) DETECTOR AND COMPUTER EVALUATION. Pethes, G. (Univ. of Veterinary Science, Budapest); Idei, A.; Sas, B.; Simonits, A.; Szabo, E. pp 343-357 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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To overcome problems met in the destructive chemical analysis of biological samples, neutron activation analysis by an instrumental method was developed to determine trace elements in liver biopsy samples from cattle. A gamma spectrometer consisting of a 45-cm$^3$ Ge(Li) detector and a 1024-channel analyzer was used with computer evaluation of gamma spectra. To diminish the sodium interference, especially during copper determination, a 3 in. × 3 in. NaI(Tl) detector was added to the assembly to perform an additional Ge(Li)–NaI(Tl) coincidence measurement to improve the selectivity of the system for copper. The value of this method for multi-element trace-element analysis is emphasized and data for atomic absorption spectrophotometry are presented for comparison. (auth)

**22097** METHOD AND EQUIPMENT FOR THE AUTOMATIC DETERMINATION OF N, P, K, and Ca IN PLANTS BY NEUTRON ACTIVATION ANALYSIS. Srapenyants, R. A.; Kovtoun, Yu. L.; Vernin, E.; Aude, G.; Axelrad, C. pp 373-384 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972). (In French).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

The determination of nitrogen, phosphorus, potassium, and calcium in plants is based on the use of nuclear reactions induced by fast neutrons and giving rise to $^{30}$P, $^{28}$Al, $^{13}$N, $^{38}$K, and $^{44}$K, respectively. After irradiation by 14 MeV neutrons the samples are counted twice, the first time to determine the amount of N, P, and K present and the second time to determine Ca. The complex gamma spectrum measured during the initial counting is analyzed quantitatively by the method of least squares. For an analysis rate of 500 samples per 8-h day, the relative standard deviations for the determination of N, P, and K are better than 10%, while that for calcium is 20%. The latter value is 15% when the rate is 200 samples per day. The unit comprises: a generator with a neutron yield of 2 × 10$^{10}$ n/sec, a pneumatic system, two 4" × 4" NaI(Tl) detectors stabilized with respect to energy, a DIDAC analyser, a single-channel scaler, and a T-2000 computer for automatic operation of the unit, processing of complex gamma spectra, calculation, and print-out of the results of the determinations. (auth)

**22098** NEUTRON ACTIVATION ANALYSIS FOR STUDYING THE ROLE OF HUMIC ACIDS DURING TRANSPORT OF TRACE ELEMENTS IN THE MARINE BIOCYCLE. Huljev, D.; Strohal, P. (Institut Rudjer Boskovic, Rovinj, Yugoslavia). pp 385-390 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Neutron activation analysis was applied to the qualitative and quantitative determination of trace elements in humic acids of marine origin, and in their hydrolysis products. The trace elements measured were Fe, Co, Sc, Sb, Eu, Cs, Se, Ag, and Sr. The concentrations obtained ranged from $10^{-2}$ to $10^{-8}$ g of a certain microconstituent per gram of sample. The results concerning the role of humic acids in the cycle of trace elements in marine biocycle are discussed. The experimental data are compared with the laboratory experiments dealing with the determination of stability constants for metal complexes of humic acids and their hydrolysis products. From these data it is possible to suggest the ecological importance of trace elements bonded to humic acids in a certain region. (auth)

**22099** BIOCHEMISTRY OF THE TRACE ELEMENTS. Bowen, H. J. M. (Univ. of Reading, Eng.). pp 393-405 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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The importance and current state of elementary analysis, including activation analysis, is discussed with respect to biochemistry. Reasons are advanced for the lack of relevance of much activation work to current trends in academic biochemistry; possible ways of improving this situation are suggested. The present status of the biochemistry of the trace elements arsenic, boron, bromine, cobalt, chromium, copper, iron, iodine, manganese, molybdenum, nickel, selenium, silicon, tin, vanadium, and zinc, are briefly reviewed, and areas needing further study are suggested. Finally, the importance of further biogeochemical studies is stressed, in view of the need to know more about the cyclical processing of the elements in nature and their modification by industrial pollution. (auth)

**22100** RELATIONS BETWEEN CARBOHYDRATE AND TRACE-ELEMENT METABOLISMS INVESTIGATED BY NEUTRON ACTIVATION ANALYSIS. Behne, D.; Diel, F. (Hahn-Meitner Institut fuer Kernforschung, Berlin). pp 407-414 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Relationships between the metabolisms of several trace elements and glucose were investigated by analyzing the element composition of human blood serum taken from subjects in the fasting state, after oral administration of glucose, and after intravenous insulin infusion. For the multi-element determination, neutron activation analysis was employed. The serum samples were irradiated for 10 d in a thermal neutron flux of 5 × 10$^{13}$ n cm$^{-2}$ s$^{-1}$. After decay periods of two weeks and of three months the gamma-ray spectra were measured using a high-resolution Ge(Li) detector. Thus it was possible to determine the concentrations of antimony, bromine, cesium, chromium, cobalt, iron, rubidium, silver, selenium, and zinc without chemical separation. After oral administration of glucose, increases in the serum levels of chromium, decreases in those of selenium and zinc, and alterations in the cobalt contents were noted. That intravenous insulin infusion likewise leads to changes in the serum concentrations of the four elements, with marked rises in the levels of chromium and cobalt, provides further evidence that these elements may play a role in carbohydrate metabolism. (auth)

**22101** DETECTION OF VARIOUS FORMS OF NUCLEOTIDE PHOSPHORUS BY ACTIVATION ANALYSIS. Sabbioni, E.; Clerici, L.; Campagnari, F.; Girardi, F. (EURATOM–CCR, Ispra, Italy). pp 415-426 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Neutron activation analysis for phosphorus is used to measure total, terminal, and radiation released phosphorus in nucleic acid samples containing only a few micrograms of nucleotide material. The preliminary results obtained demonstrate the potential relevance of these methods either in determination of polynucleotide chain length or in studies on the radiation damage of DNA. (auth)

**22102** APPLICATION OF NEUTRON ACTIVATION ANALYSIS FOR THE DETERMINATION OF SOME MAJOR TRACE COMPONENTS IN STANDARD SERUM. Johansen, O.; Steinnes, E. (Institutt for Atomenergi, Kjeller, Norway). pp 427-436 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Neutron activation analysis can be advantageously used as one of several independent analytical techniques to establish certified values for some major components in standard serum. Work on the determination of sodium, chlorine, and potassium has been in progress for several years, and various factors affecting the precision and accuracy of the results have been systematically studied. The procedure used at present is based on irradiation of serum or standard ampoules one by one. The $^{38}$Cl and $^{24}$Na activities are recorded in the same measurements by Ge(Li) $\gamma$ spectrometry, while the $^{42}$K activity is isolated from independently irradiated samples by a quantitative tetraphenylborate precipitation and subsequently measured by $\gamma$ spectrometry using a NaI(Tl) well-type detector. A precision of about 0.7% for Na and Cl (standard deviation of a single value) and 1.5% for K has been obtained. Work on trace constituents in standard serum has so far been limited to the development of methods to determine total concentrations of iodine and cobalt. Specific and rapid radiochemical procedures for the isolation of $^{128}$I and $^{60m}$Co from irradiated serum samples have been established. To determine I, no extensive decomposition step is necessary. After heating the irradiated sample for 10 min with 5N NaOH in the presence of iodide carrier, and subsequent reduction of possible iodine atoms in a higher oxidation state, a procedure based on $CCl_4$ extraction and AgI precipitation is applied. This treatment appears to include the radioactive iodine atoms originating from organic sites, as shown by experiments with serum samples containing known amounts of 1-thyroxine and 3,5,3′-tri-iodo-1-thyronine. The precision for iodine determination at the 0.05-ppM level is about 4%. The separation method for cobalt, following a $HNO_3/H_2SO_4$ decomposition, is based on two anion exchange separation steps and subsequent extraction of the $\alpha$-nitroso-$\beta$-naphtholate into chloroform. The method is sufficiently sensitive to allow the determination of cobalt in serum samples down to concentrations of about 0.05 ppB ($10^9$). (auth)

**22103** RAPID DETERMINATION OF PROTEIN-BOUND IODINE BY NEUTRON ACTIVATION ANALYSIS AND SUBSEQUENT $\beta$-COUNTING. Lubkowitz, J. A.; Heurtebise, M. (Instituto Venezolano de Investigaciones Cientificas, Caracas). pp 437-447 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Protein-bound iodine (PBI) can be determined accurately by simultaneously measuring the $\beta$ activity of $^{128}$I formed by irradiation of a standard and of a sample. After eliminating iodide by means of an anionic resin in the nitrate form, the eluate, containing PBI, and a standard sample are irradiated at a flux of $10^{12}$ n cm$^{-2}$ s$^{-1}$. Subsequently the sample and standard are passed through a resin column containing an iodide specific resin. Such resin is obtained by saturating an anionic resin with a concentrated solution of $I^-/I_2/I_n^-$. This sequential resin treatment eliminates the anionic interferences present before irradiation, and the cationic interferences formed after irradiation. Samples and standards, each retained on separate iodinated resins, are placed in two identical flow-type GM counters that have been designed for measuring reproducible $\beta$-activities retained on the resins. The design, consisting of a cylinder containing two anodes and a cylindrical aluminum tube placed longitudinally in the centre, is used to introduce small resin columns into the counter. Small amounts of resins can be placed within ±1 cm of the counter's centre without affecting the counting rate. The signal of the twin GM counters are fed to a newly developed automatic ratio scaler that has been programmed to provide direct digital display of the nanograms of iodine in the sample. Good scheduling between irradiation, radiochemical separation, and counting permits the complete analysis of 84 samples per day by one operator. A standard deviation of 7.2% is obtained for samples containing 58 ng/ml of PBI. (auth)

**22104** TRACE ELEMENTS IN NORMAL MAMMALIAN TISSUE AND CORRESPONDING MALIGNANT TUMOURS. Schicha, H. (Kernforschungsanlage, Juelich, Ger.); Kasperek, K.; Riedel, V.; Feinendegen, L. E.; Vyska, K.; Mueller, W. pp 451-459 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Trace-element concentrations vary widely between various biological tissues. Also, within one man and within one single homogeneous organ, trace elements are distributed heterogeneously. These differences of trace-element content show some interdependence, which occurs mainly in the case of the essential trace elements. Correlations between concentrations of various trace elements were observed when mean values for different organs as well as different values within one single organ were compared. Also, in malignant tumors special trace-element correlations were observed. An explanation of these data has not been possible up to now. More examinations are necessary. The special distribution patterns observed may be the result of coupled metabolic reactions. The data are based on the neutron activation analysis of Ag, Co, Cr, Cs, Fe, P, Rb, Sb, Sc, Se, and Zn in about 500 human autopsy tissue samples. (auth)

**22105** MEASUREMENT BY NONDESTRUCTIVE NEUTRON ACTIVATION ANALYSIS OF BROMINE CONCENTRATION IN THE SECRETIONS OF NURSING MOTHERS. Khalkhali, Z. (Univ., Teheran); Parsa, B. pp 461-467 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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A study was made of secretional pathways of bromine in nursing mothers. Ten nursing subjects were given a dose of 0.5 g Br/50 kg weight, and the changes in the bromine concentration in their plasma, milk, sweat, and urine were measured over a period of one week. Activation analysis of the collected samples was performed by irradiation at the Tehran University Research Reactor in a thermal flux of $2 \times 10^{13}$ n cm$^{-2}$ s$^{-1}$ for a period of 1 h. The irradiated samples were analyzed by a Ge(Li) detector and an 800-channel analyzer. The bromine concentration in the plasma and observed body secretions reached its maximum after 48 h. In the case of plasma it then fell giving a biological half-life of about 4 d and later leveled off to a longer decay period. Bromine concentration in urine tended to become steady after the 48-h peak. In the case of milk, a sharp decline with a biological half-life of about 3 d followed the observed peak in the second day. A similar situation was obtained with sweat where the excretion of bromine was mainly in the first few days. Measurement of bromine concentration in the plasma and body secretions of various individuals revealed that those with higher standards of living had a bromine concentration about three times greater than that of people with low living standards. It was concluded that the bromine has a cumulative effect in the body. By comparison, the tissues have a higher bromine binding capacity than the plasma components. The high rate of bromine excretion in the milk suggests a significant poisoning route in case of mothers who breast-feed their newborn infants and take bromine compounds as medication. (auth)

**22106** USE OF $^{46}$Ca TO MEASURE CALCIUM ABSORPTION IN THE NEONATE. Barltrop, D. (St. Mary's Hospital, London); Sutton, A. pp 479-485 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Tracer investigations can be done in human babies or children without any exposure of the subject to ionizing radiation. A good example is the use of $^{46}$Ca as a marker for measuring calcium absorption in bottle-fed, newborn infants and this has now been done for the first time. A trace amount of calcium enriched in $^{46}$Ca is administered to the infant as a solution of the chloride mixed with a normal feed. After the feed, urine and feces are separately collected and specimens of blood may be taken. The $^{46}$Ca content of the samples is estimated using the technique of neutron activation analysis. Results from this investigation are presented. (auth)

**22107** COPPER ANALYSIS OF NAIL CLIPPINGS FOR THE DETECTION OF CYSTIC FIBROSIS. Fite, L. E. (Texas A and M Univ., College Station); Wainerdi, R. E.; Harrison, G. M.; Doggett, R. pp 487-499 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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In a cooperative effort between Baylor College of Medicine and Texas A & M University, nail clippings from over 2000 subjects, including newborn infants, previously diagnosed cystic fibrosis patients, heterozygotes, and controls, were analyzed by instrumental neutron activation analysis. This study was initiated to determine the feasibility of specific elements in fingernail tissue. The study initially involved the analysis of nail clippings for their sodium content based on the method of Woodruff and Babb. However, sodium was found to be unreliable as an indicator of cystic fibrosis because of sodium contamination of the nail clippings from neonates. Other trace elements were considered and copper was the most promising as a possible indicator of cystic fibrosis based on the work of Rakovic et al. The copper content from 250 newborn infants ranged from 2 to 30 ppM, and from 2 to 40 ppM in heterozygotes and controls. Children and young adults with cystic fibrosis have shown copper concentrations from 40 to 200 ppM. However, further investigations indicated that the copper level in the nail clippings from known cystic fibrosis patients can vary substantially depending upon the condition of nails before the clipping. From one individual, copper contents of 75, 42, 13, and 53 ppM were obtained from four sets of nail clippings while eight individual sets of fingernails from another subject yielded copper levels of 73, 89, 82, 64, 78, 77, 52, and 57 ppM. Because of the infrequency of the disease, approximately one in 2000 births, considerable effort has been spent to locate newborn infants with a high probability of having cystic fibrosis to determine if the copper concentration of the nail clipping is elevated at birth. Nail clippings were received from only three neonates who have been verified as having cystic fibrosis. Although these results are inconclusive, each exhibited a normal copper level at birth and the copper level tends to become elevated when the infant reaches an age of four to six months. The results of this phase of the research and the variation in the copper concentration observed in nail clipping from known cystic fibrosis patients indicate that the copper level in nail clippings will not be a reliable indicator of cystic fibrosis in neonates. (auth)

**22108** TRACE-ELEMENT CONCENTRATIONS IN HUMAN SERUM: DIAGNOSTIC IMPLICATIONS. Kasperek, K.; Schicha, H.; Siller, V.; Feinendegen, L. E.; Hoeck, A. (Kernforschungsanlage, Juelich, Ger.). pp 517-526 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Neutron activation analysis was used to determine Co, Fe, Rb, Se, Zn, Cr, Cs, Ag, Sb, and Sc in blood serum samples from 184 healthy persons and 286 patients with various diseases. An empirical parameter based on the deviations of the concentrations of Zn, Se, Rb, and Fe from their normal average values was found to correlate with certain diseases. Patients with carcinoma had the lowest values of this parameter and those with diabetes mellitus, the highest. Zinc in normal serum showed a strong correlation with serum protein concentration. In a separate experiment involving 11 healthy individuals and one patient with pyelonephritis, the influence of food intake on the serum concentrations of trace elements was tested. Zinc showed the most marked response following a large meal, dropping over the course of 3 to 6 h to less than 70% of its initial fasting value. The addition of vitamin C to the meal significantly reduced the degree of this response. (auth)

**22109** SELENIUM AND CHROMIUM ASSAY IN EGYPTIAN FOODS AND IN BLOOD OF EGYPTIAN CHILDREN BY ACTIVATION ANALYSIS. Maxia, V. (Univ., Pavia, Italy); Meloni, S.; Rollier, M. A.; Brandone, A.; Patwardhan, V. N.; Waslien, C. I.; El Shami, S. pp 527-550 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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The investigation was focused on chromium and selenium since both are recognized as essential trace elements for animals. The aim was to gather information on some malnutrition diseases typical of Egypt. Selenium and chromium were determined both in blood and foodstuffs by neutron activation analysis and gamma spectrometry with NaI crystals. Selenium in blood samples was instrumentally determined as $^{77m}$Se after removing interferences due to sodium by dialysing the samples before irradiation. Selenium assay in foodstuffs was carried out by a destructive procedure after activating $^{75}$Se. The chemical procedure was based on selenium metal precipitation after removal of interfering activities. For chromium assay both in blood and foodstuffs, a destructive procedure was also necessary, based on barium chromate precipitation and successive extraction with methyl isobutyl ketone. Results of selenium and chromium assays in over 100 various foodstuffs and in over 200 blood samples are reported and discussed. Chromium values in blood were found to be within the reported ranges, whereas the mean value for Se in whole blood of young adults is 50% lower than values reported for United States and Guatemalan adults. To check this difference blood samples were analyzed for Se by using the longer activation of $^{75}$Se, and the results confirmed those obtained by the instrumental technique on $^{77m}$Se. As in foodstuffs, the ranges of values obtained both for Se and Cr vary extremely; the more informative median values within any particular foodstuff are reported. The preparation of foodstuff samples, either by oven-drying or freeze-drying, is also discussed. (auth)

**22110** FLUORINE CONCENTRATION IN THE ENAMEL AND DENTIN OF NORMAL AND MOTTLED HUMAN TEETH. CORRECTION FOR DEAD-TIME VARIATIONS DURING INSTRUMENTAL ANALYSIS FOR $^{20}$F. De Aisenberg, E. Y.; Cohen, I. M.; Korob, R. O.; Rudelli, M. D. (Comision Nacional de Energia Atomica, Buenos Aires). pp 551-560 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972). (In Spanish).

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The instrumental analysis of biological material for fluorine using reactor neutrons is difficult. The nuclides produced by the reactions $^{19}$F(n,$\gamma$)$^{20}$F, $^{19}$F(n,p)$^{19}$O and $^{19}$F(n,$\alpha$)$^{16}$N all involve the same disadvantages from the point of view of analysis: very short half-lives; low activation cross-sections; and the fact that oxygen interferes in the last two reactions. With fission neutrons, the yield of the reaction $^{19}$F(n,2n)$^{18}$F is extremely low owing to the high threshold value. The fluorine in samples of enamel and dentin from normal and mottled human teeth (the latter being obtained in areas where there is endemic fluorosis) was determined by irradiating the samples for 30 sec in the RA-3 reactor and, after rapid transfer, measuring the 1633.7-keV gamma line of the $^{20}$F by means of a Ge(Li) detector connected with a 4096-channel analyser. As the very short half-life of $^{20}$F ($T_{1/2}$ = 11.4 sec) makes it impossible to do measurements on a standard sample irradiated at the same time as the samples being investigated, the internal-standard technique was employed; with this technique, known amounts of fluorine are added, after an appropriate decay period, to the samples already irradiated and measured, and the latter are then irradiated and measured once more. Variations in the neutron flux were determined by using the activity of the total energy peak of the $^{49}$Ca 3084.4-keV gamma line. By using a Ge(Li) detector it is possible, despite its relatively low efficiency, to measure the $^{20}$F without interference from $^{38}$Cl, with gamma activity of a similar level (1642.7 keV), or from the high activity of the $^{28}$Al produced by the reaction $^{31}$P(n,$\alpha$)$^{28}$Al, which involves one of the main matrix components. The fact that the active measurement times differed for the consecutive irradiations of each sample made it necessary to derive equations for correcting the activity of the nuclides for decay during the measurement period. In deriving these equations, modifications to the guidelines laid down by Junod are proposed. The experimental detection limit was 50 ppM, which is better than the theoretical limit (without interference) and agrees with other authors' estimates of the practical limit. (auth)

**22111** NEUTRON ACTIVATION ANALYSIS OF ARSENIC, MANGANESE, AND SELENIUM CONCENTRATIONS IN ORGANS OF URAEMIC AND NORMAL PERSONS. Larsen, N. A. (Municipal Hospital, Copenhagen); Nielsen, B.; Pakkenberg, H.; Christoffersen, P.; Damsgaard, E.; Heydorn, K. pp 561-568 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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In seven patients who had died from chronic renal insufficiency and in seven previously healthy persons who had died in accidents, the concentrations of arsenic, manganese, and selenium in peripheral nerves, muscle, kidney, liver, spleen, pancreas, and lung were determined by neutron activation analysis. No metal was allowed near the organs sampled. The plastic tools used for the dissection were analyzed to exclude contamination from this source. Samples were transferred directly to polyethylene irradiation containers and weighed, so that all concentrations of trace elements refer to wet sample weight. An activation analysis method was developed to simultaneously determine the three elements. The method consisted in decomposing the irradiated material in nitric-acid–sulfuric acid followed by separating selenium, arsenic, and manganese. The activities of $^{76}$As, $^{56}$Mn, and $^{81m}$Se were measured by gamma-ray spectroscopy. Chemical yields were determined by added $^{54}$Mn tracer and by re-irradiation of the separated arsenic and selenium samples. Arsenic concentrations in normal man ranged from 0.3 ng/g in a spleen to 20 ng/g in lung and liver, corresponding to a logarithmic range of 1.80;

the coefficient of variation between individuals was about 60%. The average concentration in all organs sampled was higher in the uremic patients. Manganese concentrations in normal man ranged from 33 ng/g in a peripheral nerve to 1450 ng/g in pancreas, corresponding to a logarithmic range of 1.65; the coefficient of variation between individuals was about 25%. In the uremic patients, significantly lower concentrations were found in kidney. Selenium concentrations in normal man ranged from 56 ng/g in a peripheral nerve to 790 ng/g in kidney, a logarithmic range of 1.15; the coefficient of variation between individuals was also about 25%. In the uremic patients concentrations were significantly lower in kidney and spleen. The possible biological, nephrological, and neurological implications of the results are discussed. (auth)

**22112** PRODUCTION OF A UNIFORM NEUTRON FLUENCE IN A MAN-LIKE PHANTOM AND DETERMINATION OF TOTAL-BODY SODIUM IN HUMANS BY NEUTRON ACTIVATION ANALYSIS. Anderson, J. (King's Coll., London); Battye, C. K.; Osborn, S. B.; Tomlinson, R. W. S.; Fry, F. A.; Newton, D. pp 571-588 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Measurements are reported that show the difference between slow neutron flux distributions produced in a phantom by two similar irradiations at different establishments, and the limitations in the method of estimating flux distributions from bilateral irradiations using data obtained from a single unilateral irradiation. Two methods that might be used to obtain a uniform distribution of slow neutron fluence throughout a live human subject are described. It was concluded that a method in which the subject is moved through a collimated beam of 14-MeV neutrons, while lying in a rectangular tank containing moderating material, is capable of providing a highly uniform neutron fluence over a region of the tank capable of accommodating most subjects. Results of the measurement of slow-neutron fluence are given, as well as measurements of the $^{24}$Na activity induced in parts of a man-phantom irradiated by this method. Measurement by neutron activation analysis of the total sodium contents of six healthy male volunteers and three man-like phantoms of different sizes are reported. The subjects were irradiated by the scanning method and the induced activity compared with that produced in a standard man-like phantom containing sodium carbonate solution. Exchangeable sodium was also measured in the volunteers. The results are compared with those reported previously by other workers. The possibility that the slow neutron flux was depressed by the presence of the phantoms and live subjects is examined and it is concluded that further work is required to establish the magnitude of this effect. (auth)

**22113** LOW-COST FACILITIES FOR PARTIAL-BODY AND TOTAL-BODY IN-VIVO ACTIVATION ANALYSIS IN THE CLINICAL ENVIRONMENT. Boddy, K.; Holloway, I.; Elliott, A.; Glaros, D.; Robertson, I.; East, B. W. (Scottish Universities Research Centre, Glasgow). pp 589-603 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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A simple and relatively inexpensive system has been designed which is intended ultimately for use in the clinical environment. An outline description of the system is presented. In designing afresh a facility for total-body in-vivo activation analysis, some factors considered were: patient amenity—minimizing distress to the patient by using a natural geometry; close proximity of irradiation and monitoring facilities to reduce decay times and hence the radiation dose to the patient; low cost; simultaneous bilateral irradiation and maximum uniformity of activation compatible with patient comfort; and simultaneous determinations of several body elements of clinical interest. The relationship of these factors to a facility just constructed is critically assessed in the light of the preliminary measurements made so far. A number of problems involving the balance of scientific finesse and patient amenity are outlined and discussed. (auth)

**22114** PARTIAL-BODY IN-VIVO NEUTRON ACTIVATION OF CALCIUM IN BONE. Appleby, D. B.; Burkinshaw, L.; Marshall, D. H.; Oldroyd, B.; Oxby, C. B. (Univ. of Leeds, Eng.). pp 617-625 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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The clinical assessment of bone mineralization is frequently made in terms of the mass of calcium per unit volume of bone. This was measured both by analysis of biopsy specimens and by gamma absorption techniques. Preliminary work to estimate the amount of calcium, and other elements, which can be determined in selected skeletal sites using partial-body, in-vivo, neutron activation analysis is described. The two sites chosen are the distal ends of the radius and ulna, and the distal end of the femur. Models of these sites were constructed and the bones (or their analogues) filled with known activities of radioisotopes that emit gamma rays having energies similar to those of the chosen element. The detection system used was a 70-cm$^3$ Ge(Li) detector, placed in a reproducible geometry with respect to the model. The sensitivities of detection of various gamma rays were measured and detection efficiencies then calculated for radioisotopes induced by neutron irradiation. The time integral of neutron flux, which could be used in practice, was derived from a knowledge of bone dosimetry. The amount of calcium and other elements in the selected sites of irradiations was determined from published data. From the three parameters, i.e. counting sensitivity, neutron flux and mass of element, the feasibility of partial-body neutron activation for the determination of bone mineralization was assessed. Comparison with other techniques was made. (auth)

**22115** QUANTITATIVE AND SERIAL STUDIES OF TOTAL-BODY CALCIUM (BONE MASS) IN MAN BY IN-VIVO ACTIVATION ANALYSIS. Nelp, W. B.; Denney, J. D.; Murano, R.; Hinn, G. M.; Chesnut, C. H. (Univ. of Washington, Seattle). AT(45-1)-2046. pp 627-638 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

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Using the technique of total-body neutron activation analysis (TBNAA) 200 examinations were made in 114 patients with various disorders of calcium metabolism and in eight normal subjects. The system of TBNA uses the University 60-in. cyclotron which produces a uniform body exposure of 200 mrad of 4 to 12 MeV neutrons in 90 s. Total-body counting requires 12 min, and techniques for measuring comparator calcium standards and for checking performance stability are part of the automated analytical system. Analysis of cadavers, activated and subsequently chemically analyzed, established a basis for quantitating total-body calcium (TBC) in grams with an estimated accuracy of ±5%. Serial measurements of the same subject are reproducible with an overall coefficient of variation of ±2.3%. In normal man, TBC can be characterized by the expression, TBC (g) = 0.203 height$^3$ (m). In eight normal adult males, TBC ranged from 933 to 1361 g, average 1.093 g. In 34 subjects with carefully documented idiopathic osteoporosis, skeletal mass (TBC) was reduced by as much as 35% from the estimated normal. Severe reduction in TBC was documented in patients with advanced multiple myeloma, Cushing's syndrome, and osteomalacia. TBC is normal or only slightly reduced in a group of 24 patients with chronic renal failure on maintenance hemodialysis. In these patients, serial studies were correlated with calcium absorption, bone biopsy, x-ray and photon absorption densitometry of bone, and renal osteodystrophy. TBNA calcium balance studies have provided useful clinical data for detection of hyperparathyroidism, for adjusting dialysate concentrations of calcium in long-term hemodialysis, for measuring the effect of therapy on osteoporosis, and for evaluating the effect of bed rest (simulated weightlessness) on bone wasting. (auth)

**22116** MEASUREMENT OF WHOLE-BODY NITROGEN BY NEUTRON ACTIVATION ANALYSIS. Biggin, H. C.; Chen, N. S.; Ettinger, K. V.; Fremlin, J. H.; Morgan, W. D.; Nowotny, R.; Chamberlain, M. J. (Univ. of Birmingham, Eng.). pp 639-649 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

Measurement of nitrogen balance is a standard tool in the study of protein metabolism and nutrition. It is used sparingly in research and rarely in the routine clinical situation because of the expense of a conventional metabolic ward. The same information may be obtained by whole-body nitrogen measurement by neutron activation analysis, a procedure taking a few minutes and repeated about every month. The patient is placed on a motorized couch that scans across a well-collimated beam of neutrons produced on the Nuffield cyclotron at Birmingham. Neutrons are produced by bombarding a lithium target with 10-MeV protons, the fast neutrons from this source slowing down to thermal energy in about 15 μs, then diffusing about in the body for several hundred microseconds. Therefore, the neutrons are pulsed in repetitive cycles consisting of 15 μs irradiation, 5 μs wait-time and 150 μs counting period during which the 10.83-MeV gamma ray from slow neutron capture in $^{14}$N is measured. Two 15.2 cm × 15.2 cm NaI(Tl) detectors are positioned one on each side of the patient, and a 12.7 cm × 12.7 cm NaI(Tl) detector is suspended above the patient, just out of the direct neutron beam. Each detector is shielded against the general background gamma radiations and scattered neutrons by an inner lead annulus with an outer annulus of LiF-doped wax or polyester, and the three detectors are linked to a computer-based analyzer system. This computer is programmed to separate nitrogen counts from background due to pulse pile-up in this region by generating a curve that joins the smooth slopes on either side of the gamma-ray peaks. It is possible to gain information on relative nitrogen distribution along the length of the body by using a modified technique whereby the scan comprises a series of discrete measurements on different parts of the body. Preliminary measurements on inanimate phantoms indicate that a statistical accuracy of about 1% for relative nitrogen determination is attainable at a dose to the patient of 0.1 rem. It is hoped to present results of the first clinical studies. (auth)

**22117** TRACE ELEMENTS IN CLAMS, MUSSELS, AND SHRIMP. Bertine, K. K.; Goldberg, E. D. (Institut Royal des Sciences Naturelles de Belgique, Brussels). Limnol. Oceanogr.; 17: No. 6, 877-884(Nov 1972).

Compositional changes in the trace element content of shells of mussels and clams that might be related to man's influence on the composition of inshore marine waters over the past hundred years were sought but not found. The elements Rb, Fe, Co, Sb, Sc, Ag, Cr, Zn, Se, and Hg were analyzed in freshly caught and museum specimens by instrumental neutron activation analysis. Contamination from the preservations was evident in the shells and tissues of museum specimens. Elemental concentrations in the calcareous shells, both aragonitic and mixed aragonitic-calcitic, are similar and may reflect the composition of the waters in which they lived, rejection by the organisms, or surface associated features. The proteinaceous molts of shrimp contained high levels of these elements, in agreement with previous investigations. With 20 to 25 molts per shrimp per year, the molting of shrimp can cause a redistribution of these elements within the marine environment. (auth)

**22118** METHOD FOR THE DETERMINATION OF GOLD IN ROCKS BY NEUTRON ACTIVATION ANALYSIS. Anastase, S.; Cercasov, V. An. Univ. Bucuresti, Chim.; 18: No. 1, 111-121 (1969). (In Rumanian).

A rapid method for the determination of gold in ores and rocks by neutron activation analysis is described. The determination is executed with the radioisotope $^{198}$Au obtained by the irradiation of the natural isotope $^{197}$Au at a neutron flux of $1 \times 10^{13}$ n/cm$^2$. sec, for 10 hours. Any chemical treatment is avoided, the activity of $^{198}$Au being determined on the background produced by the induced activities of the other elements from the matrix by the study of the $\gamma$ spectra, obtained with a 400-channel analyzer using Covell's method. Precision was established by the determination of gold ratio in samples with standard addition. The method, at this stage, has a precision of ±10% and a sensitivity of 0.5 ppM; it is recommended particularly for the determination of gold in ores and rocks containing As $\leq$ 1%. (auth)

**22119** NEUTRON ACTIVATION ANALYSIS FOR FLUORITE IN ORE ON A CONVEYOR BELT. Ivanov, I. N.; Markun, N. Yu.; Shtan, A. S. Tr. Vses. Nauch.-Issled. Inst. Radiats. Tekh.; No. 6, 131-134(1971). (In Russian).

The fluorite content of ore moving on a conveyor belt is continuously determined by measuring the $^{16}$N produced in the $^{19}$F(n,$\alpha$)$^{16}$N reaction. The analysis is conducted on a layer of ore of size 200 cm × 15 cm × 5 cm moving at 15 cm/sec., and a $^{238}$Pu–Be source with an output of $1.52 \times 10^7$ neutrons/sec. and a single-channel scintillation $\gamma$-ray spectrometer with a NaI(Tl) crystal are used. The distance between the source and the detector is 140 cm. Calibration is with prepared mixtures of $CaF_2$ and sand. Variation in the moisture content of the ore from 0 to 20% does not affect the results, and increase in the bulk density from 1.6 to 2.1 g/cu. ml increases the intensity of the $\gamma$-radiation from the $^{16}$N proportionately. Thus, ores can be analyzed without measurement of density or moisture content. The sensitivity is 15 counts/min. with 1% of $CaF_2$, and the limit of detection with a background of 120 counts/min. is 1.45% of $CaF_2$. (Referativnye ZH)

**22120** RADIOACTIVATION DETERMINATION OF GOLD USING ITS ION EXCHANGE SEPARATION UNDER CONDITIONS CLOSE TO SUBSTOICHIOMETRIC ONES. Nikanorov, G. S.; Kist, A. A. (Inst. of Nuclear Physics, Tashkent). Zh. Anal. Khim.; 27: No. 12, 2438-2441(Dec 1972). (In Russian).

A method is suggested for the radiochemical separation of gold in the radioactivation analysis of rocks. The method, using limit loadings of the sorbent, allows the radiochemical purity of the sample to be increased. The sensitivity of the method is $10^{-8}$% Au when a 5 g sample is used at a flux of $10^{13}$ n · cm$^{-2}$sec$^{-1}$. The method can be used for the analysis of natural waters and pure materials. The principle of using sorbents with limit loadings is applied to preliminary concentration of gold. (auth)

**22121** DETERMINATION OF IRON IN GOLD BY RADIOACTIVATION. Blachot, J.; Palleau, J. (CRNS, Grenoble, France). Anal. Chim. Acta; 63: No. 1, 241-245(Jan 1973). (In French).

The $^{54}$Fe(n,p)$^{54}$Mn reaction was chosen for the detection of Fe in Au because the loss of Fe during the dissolution is <0.2% and because of the absence of a screening effect by the matrix. The principle of the method consists in the irradiation of the sample with fast neutrons in a reactor, the dissolution of the sample, the separation of the $^{54}$Mn on resins, and the determination of the $^{54}$Mn by $\gamma$ spectrometry. The method furnishes satisfactory results in the range from 9 to 300 ppM. (JSR)

**22122** INSTRUMENTAL MULTI-ELEMENT ACTIVATION ANALYSIS OF BIOLOGICAL TISSUE AND ITS APPLICATION TO THE INVESTIGATION OF METALLOSIS. Lux, F.; Zeisler, R. (Technische Univ., Garching, Ger.). Z. Anal. Chem., 261: No. 4-5, 314-328(1972). (In German).

The usefulness of multi-element determinations in biological tissue by instrumental activation analysis, using reactor irradiation and $\gamma$ spectrometry in investigation of metallosis was evaluated. In one sample (100 to 200 mg fresh tissue, lyophylized) 9 elements can be determined instrumentally in one run (detection limits in ppM in parenthesis): Cr (0.1), Fe (5), Co (0.01; 0.001 if measured 6 months after irradiation), Ni (0.5), Zn (0.5), Mo (0.07), Ag (0.1), Sb (0.01), and Ta (0.005). Only the manganese determination (0.01) needs a chemical step for $^{24}$Na separation. The different elements were present in a range of 0.01 to 3000 ppM. For high counting rates with a low error $\sigma$ due to counting statistics the overall standard deviations were $s \leq 0.5\%$. Counting error values are given for various contents of the different elements, because for low contents $\sigma$ is dominant. The metallic components of V4A-steel (Fe, Cr, Ni, Mo, Mn) can be determined instrumentally by a single analysis of one sample only. The results of this determination of main components by instrumental activation analysis are in good agreement with the results obtained by other analytical methods. Thirty eight clinical cases of metallosis were investigated. The metallic components of V4A-steel as well as the biological trace elements Co, Zn, Sb were determined in tissue samples taken at different distances from the implant. These activation analyses together with investigations by electron diffraction and by electron microscopy lead to the following conclusions: Crystallites are split off from the implant by transcrystalline corrosion and further decomposed to micro-crystallites. After the complete corrosive destruction of the V4A-microcrystallites nickel and molybdenum are quickly removed. Chromium is removed at a lower rate. Iron forms a compound in the cells. This compound is slowly degraded. In metallosis tissue the zinc content is decreased probably due to a displacement of the enzyme bonded zinc by the components of the implant. This could influence the development of metallosis. The tissue content of the biologically unessential antimony remains unchanged by metallosis. (auth)

**22123** IMPURITY DEPTH PROFILES BY MICROANALYSIS TECHNIQUES. Dunning, K. L.; Hughes, H. L. (Naval Research Lab., Washington, DC). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 243-248(Dec 1972).

From Annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707–.

A method for determining the depth profile of aluminum atoms near the surface of $SiO_2$ has been demonstrated by means of a sharp $^{27}$Al(p,$\gamma$)$^{28}$Si resonance. The proton beam from the NRL 5-MV Van de Graaff is passed through two beam-energy analyzers and allowed to fall upon the specimen located in the well of a sodium-iodide gamma-ray detector. The gamma-ray yield is measured as the beam energy is varied in small steps throughout a neighborhood in the vicinity of the resonance energy. The shape of the resulting yield curve depends upon the impurity (implanted) atom profile, the resonance shape, the beam energy distribution, the mean energy loss of the protons as they penetrate the specimen, and the fluctuations about this mean. All factors except the impurity atom concentration depth profile are assumed known and the concentration profile is extracted from the data by iterative syntheses of the yield curve shape and comparison by means of a computer. Depth resolution of the order of 100 Å is practicable near the bombarded face of the specimen. The method is capable of an absolute measurement of the number of impurity atoms but that has not been demonstrated. The results are compared with those from a Cameca ion-beam mass spectrometer. (auth)

## ***Chemical and Spectral Procedures***

*Refer also to abstract 22289.*

**22124** (AERE-R-6855) DETERMINATION OF OXYGEN IN MOLTEN SODIUM BY FUSED SALT POLAROGRAPHY. A Feasibility Study. Rowlands, D. L. G.; Watson, P. G. (Atomic Energy Research Establishment, Harwell (England)). Aug 1972. 44p. Dep. NTIS (U. S. Sales Only). UK £1.00.

A polarographic method was investigated for the determination of oxygen at the ppM level in sodium. The technique utilizes the molten metal as a rising drop polarographic electrode in a fused salt electrolyte. Reasons for the selection of the technique are discussed, and the design and operation of the equipment described. Background current-voltage curves obtained with the apparatus using pure sodium are reported, and technical problems requiring further development are discussed. Relevant data and a detailed description of the apparatus are given in the appendices. (auth)

**22125** (FOA-4-4501-A-2) METHOD FOR THE DETERMINATION OF HYDROGEN, NITROGEN, AND OXYGEN IN PLUTONIUM BY VACUUM FUSION-GAS CHROMATOGRAPHY. Alm, K. -F.; Andersson, L. -H. (Forsvarets Forskningsanstalt, Stockholm (Sweden)). Jun 1972. 13p. Dep. NTIS (U. S. Sales Only).

A method for the determination of hydrogen, nitrogen, and oxygen in plutonium metal by a vacuum fusion technique is reported. The analytical system was connected with an induction-heated graphite crucible in a high vacuum system in a glove box for the safe handling of plutonium. The sample reacts with graphite dissolved in a liquid-metal (platinum) bath at high temperature. The gases evolved are transferred to the analytical system by means of a mercury diffusion pump. The volume of the gaseous sample is measured in the buret of an automatic Toepler-pump and then analyzed in a gas chromatograph. Evaluation of the method shows that the limits of detection of the three elements are of the order of 0.8 μg hydrogen, 3.0 μg nitrogen, and 2.5 μg oxygen. (auth)

**22126** (HEDL-SA-487) ANALYSIS OF Pu-U OXIDES BY DIRECT READING EMISSION SPECTROMETRY. Ko, R. (Hanford Engineering Development Lab., Richland, Wash.). 15 Sep 1972. Contract AT(45-1)-2170. 7p. (CONF-721070-1). Dep. NTIS.

From ASCE annual and environmental meeting; Houston, Texas, USA (16 Oct 1972).

The direct reading emission spectrometric system for analyzing plutonium-uranium mixed oxide fuels is described. Gallium oxide was used as carrier for most of the elements and sodium fluoride for elements such as Ca and Ti. (DHM)

**22127** (IS-3032) BIBLIOGRAPHY OF MASS SPECTROSCOPY LITERATURE FOR 1971 COMPILED BY A COMPUTER METHOD. Capellen, J.; Svec, H. J.; Jordan, J. R.; Sun, R. (comps.). (Ames Lab., Iowa). Feb 1973. Contract W-7405-eng-82. 618p. Dep. NTIS.

A report covering the year 1971 is presented that lists 5923 articles of interest to mass spectroscopists. The report consists of three sections; a Bibliography section, an Author Index section, and a Key Work Out of Context Index (KWOC Index) section. The Bibliography section lists the authors, the title and the publication data for each article. The Author Index lists the authors' names and the reference numbers of their articles. The KWOC Index lists the key words, the reference numbers of the articles in which the key word appears and the first 100 characters of the title. (auth)

**22128** (JAERI-1222) DETERMINATION OF ALUMINUM, IRON, COPPER, MOLYBDENUM, MANGANESE, NICKEL, AND COBALT IN BERYLLIUM BY EXTRACTION-PHOTOMETRIC METHODS WITH 8-QUINOLINOL AND OTHER REAGENTS. Tamura, N.; Motojima, K. (Japan Atomic Energy Research Inst., Tokyo). Jun 1972. 11p. (In Japanese). NTIS (U. S. Sales Only).

In the determination of impurities in beryllium, extraction-photometric methods were adapted, and the following reagents were used: 8-quinolinol for aluminum, iron, copper, and molybdenum, 2-methyl-8-quinolinol for manganese, dimethylglyoxime for nickel, and zinc diethyldithiocarbamate for cobalt. The reproducibility and accuracy of the methods were satisfactory. The limits of determination of these elements were about a few ppM. (auth)

**22129** (LA-5188-PR) EVALUATION OF METHODS FOR DETERMINING MERCURY. LASL Project R-060. Quarterly Report, October 1-December 31, 1972. Campbell, E. E.; Wood, G. O.; Trujillo, P. E.; Stein, P. (Los Alamos Scientific Lab., N. Mex.). Feb 1973. Contract W-7405-eng-36. 9p. Dep. NTIS $3.00.

Four methods for the determination of mercury in air, urine, blood, and tissue were evaluated during this quarter. Studies performed for the development of the air sampling procedure included additional break-through determinations using a mercury vapor in air generator. Interlaboratory comparisons of analyses of tubes containing air samples of mercury were made between NIOSH and LASL laboratories. The development and evaluation of an analytical method for determining mercury in urine were essentially completed during this quarter. Investigations of the urine procedure included measurements of effects of storage time, shipping containers, and several preservatives on retention of dissolved mercury in water and urine. A statistical study of the urine analytical procedure was also conducted. Tentative methods for tissue and blood were written based on a limited number of experiments and experiences with the determination of Hg in tissue, blood, and other matrices. A more thorough evaluation of both tentative methods is necessary before the methods are finalized. (auth)

**22130** (RT/CHI-(72)9) ISOTOPIC ANALYSIS AND CONCENTRATION OF URANIUM AS A ROUTINE CONTROL IN THE EUREX PROCESS PLANT. Pozzi, F.; Trincherini, P. R.; Angelini, T. (Comitato Nazionale Per L'Energia Nucleare, Rome (Italy)). 13 May 1972. 24p. (In Italian). Dep. NTIS (U. S. Sales Only). $3.25.

The control of the Eurex plant (reprocessing of irradiated fuel elements) namely that concerned with the isotopic enrichment and the determination of the concentration of uranium on input products is entrusted to analysis by mass spectrometry. The method used is based on the mixing of the sample with a spike solution of $^{233}$U, extraction in a hot cell with organic solvent (methyl isobutyl ketone) precipitation of uranium as peroxide, dissolution of the precipitate, and analysis by mass spectrometer ($CH_4$ Model B). A detailed description of the method of analysis is given and values of precision, referred to isotopic percentage or to concentration, obtained by the indicated procedure are also presented. (auth)

**22131** (RT/CHI-(72)16) SEPARATION AND DIRECT DETERMINATION OF MICRO-MACRO QUANTITIES OF URANIUM IN PROCESS EFFLUENT. Canonico, A.; Pompei, V. (Comitato Nazionale Per l'Energia Nucleare, Rome (Italy)). 11 Oct 1972. 26p. (In Italian). Dep. NTIS (U. S. Sales Only) $3.50.

A liquid-liquid TBP 30% in hexone extraction procedure is described for the separation and direct spectrophotometric thiocyanate determination of uranium in the organic extract. The method is applicable to the determination of microgram to milligram amounts of uranium in the presence of large quantities of diverse ions and is especially suitable for the separation and determination of uranium from ITREC reactor fuel element reprocessing solutions. (auth)

**22132** USE OF AN ENERGY-DISPERSIVE X-RAY SPECTROMETER IN ELECTRON-BEAM MICRO-ANALYSIS. Ryder, P.; Baumgartl, S. (August Thyssen-Huette AG, Duisburg, Hamborn, Ger.). Arch. Eisenhuettenw.; 42: No. 9, 635-641 (1971). (In German).

The use of the spectrometer was studied, in conjunction with a scanning electron microscope and with an electron microprobe, by examination of "pure" aluminium, titanium, iron, zinc, zirconium, and gold, and detection limits for Si, Mn, and Cu were determined by examination of $Na_2B_4O_7$ melts. Results were compared with those obtained by using a crystal spectrometer.

**22133** EXPERIENCE GATHERED IN THE TREATMENT OF AMMONIUM SALTS FOR MASS SPECTROMETRIC PRECISION ANALYSIS ON $^{15}$N IN THE REGION OF NATURAL ISOTOPIC ABUNDANCE. Schaaf, M.; Rolle, W. (Zentralinstitut fuer Isotopen- und Strahlenforschung, Berlin). Isotopenpraxis; 8: No. 5, 170(May 1972). (In German).

In the majority of tracer procedures with $^{15}$N, the 0.5 to 1 percent accuracy that can be achieved with single receptor methods of the mass spectrometer suffices. The higher accuracies that generally result from the double receptor principle, however, are required by problems such as natural variation of the relative abundance of $^{15}$N, distribution of highly toxic N-compounds in living organisms, and nitrogen distribution in the huge volumes of the chemical industry. Described is a method yielding an accuracy of ±0.4%. Aqueous samples, such as ammonium sulfate, are freeze-dried in an ampule. After addition of copper wire mesh, the ampule is evacuated, sealed, and heated to 600°C. The nitrogen gas is released under vacuum and pumped through a trap that is cooled by liquid nitrogen into the test tube for measurement. (HBG)

**22134** CATALYTIC WAVE OF THE CHLORATE ION IN THE PRESENCE OF NIOBIUM(V). Stepanova, I. K.; Sinyakova, S. I. (Inst. of Geochemistry and Analytical Chemistry, Moscow). Zh. Anal. Khim.; 27: No. 11, 2219-2221(Nov 1972). (In Russian).

The nature of a wave in solutions of citric acid, containing chlorate ions and Nb(V), was studied. Its catalytic character was revealed. Energy parameters for the reaction were calculated. A possibility was shown for determining $1 \times 10^{-6}$ M NB(V) by the catalytic wave of the chlorate ion in a solution of 0.5 to 1 M citric acid with satisfactory accuracy. (auth)

**22135** USE OF ELECTROGENERATED CHROMIUM(II) IN GALVANOSTATIC COULOMETRY. Kostromin, A. I.; Mosolov, V. V.; Makarova, L. L. (Kazan State Univ.). Zh. Anal. Khim.; 27: No. 11, 2114-2118(Nov 1972). (In Russian).

The behavior of chromium anode in 1 N $H_2SO_4$ solutions was studied. The yield of chromium(II) with respect to the electrolysis current is close to 100% at the current density of 0.5 to 6 $ma/sm^2$. The electrogenerated Cr(II) was used as a coulometric titrant for determining microgram amounts of $VO^{2+}$, Sn(IV), Sb(III), Bi(III), $AsO_4^{3-}$, and $MoO_4^{2-}$, in model solutions as well as for determining V, Mo, and As in alloys and salts. (auth)

**22136** INCREASE OF SPECTRAL DETERMINATION SENSITIVITY BY PLASMAJET EXCITATION. Yudelevich, I. G.; Cherevko, A. S.; Skobelkina, N. G. (Inst. of Inorganic Chemistry, Novosibirsk, USSR). Zh. Anal. Khim.; 27: No. 11, 2119-2124(Nov 1972). (In Russian).

Optimum conditions were found for determining Be, Bi, Co, Cr, Ga, La, Mn, Mo, Nb, Pb, Sb, Sn, Sc, Ti, V, Y, Yb, and Zr in rocks using plasma jet excitation. The limit of the reliable detection for the plasma jet excitation method is 0.5 to 2 orders as much as that for the arc excitation one. The comparison of the limits of the reliable detection of element traces in cesium salts for the alternating current arc, argon arc and plasma jet excitation methods showed that the plasma jet excitation method enables the determination of $10^{-4}$ to n × $10^{-7}$% of impurities. (auth)

**22137** DIRECT DETERMINATION OF ULTRASMALL AMOUNTS OF ELEMENTS BY EMISSION FLAME SPECTROPHOTOMETRY. Prudnikov, E. D. (Leningrad State Univ.). Zh. Anal. Khim.; 27: No. 11, 2129-2133(Nov 1972). (In Russian).

The method of the direct pulse evaporation of rather large samples into the flame is a promising one for photoelectric emission spectral analysis. The detection limit can be decreased by two orders and lower. The method permits direct determination of ultrasmall amounts of elements (down to $10^{-6}$ to $10^{-8}$% and less) Na, K, Li, Rb, Cs, Ca, Sr, Ga, In, Tl, Mn, Cu, Fe, Ni, Co, Cr, Ag, Yb, Ba, and Mg if 10 mg and heavier samples are used. (auth)

**22138** NEW COLORIMETRIC DETERMINATION METHOD FOR URANIUM(VI). Hodisan, T.; Suteu, A.; Gorea, V. (Babes-Bolyai Univ., Cluj). Rev. Roum. Chim.; 15: No. 4, 615-617(Apr 1970). (In German).

A method for determination of uranium was developed, which is based on the reaction between U(VI) and pyrogallol. It yields a yellow compound with an absorption maximum at 430 nm and an extinction coefficient of 3420 $mole^{-1} \times cm^3$. This method permitted the determination of 19 to 140 μg/ml U(VI). (tr-auth)

**22139** CHRONOCONDUCTIMETRIC TITRATION OF TWO-COMPONENT MIXTURES OF METAL SALTS WITH EDTA. Khudyakova, T. A.; Meshkova, L. A. Tr. Khim. Khim. Tekhnol.; No. 1, 163-166(1970). (In Russian).

Conditions for the formation of EDTA complexes with various metals were investigated. It was established that optimum pH values for conductimetric EDTA titrations are: Fe(III), 1.0; Th, 2.0; Cu(II, Pb and Ni, 3.0; Zn, Co, Cd, and Al, 4.0; Fe(II), Mn(II), and La, 5.0; Ca and Mg, 8 to 9; and Sr and Ba, 10.0. The theoretical relationships derived provide a means of finding the conditions under which one element can be determined in the presence of others. The theoretical conclusions are confirmed by analyses of solutions of binary mixtures of Th with Fe(II), La, Mn, Mg, Ca, Sr, or Ba, and also binary mixtures of Cu(II), Pb, Ni, Zn, or Co with Ca, Mg, Sr, or Ba. (Refer. Zh.)

**22140** PHOTOMETRIC DETERMINATION OF TELLURIUM IN UNALLOYED AND LOW-ALLOY AUTOMATIC STEEL. Koch, O. G. (Chemisches Laboratorium, Neunkirchen, Ger.). Anal. Chim. Acta; 64: No. 1, 156-158(Mar 1973). (In German).

Without preceding isolation, tellurium is measured directly as tellurium sol by photometry of the sample solution. Details of the method are described. Each determination requires about 40 min. In unalloyed and low alloy steels, 0.003 to 0.120% Te can be measured. No distortions are caused by Ni, Pb, V, and As. For Cr and Mo, however, certain corrections are necessary. (HBG)

**22141** DETERMINATION OF CADMIUM AND TELLURIUM IN CADMIUM TELLURIDE BY THE METHOD OF FULL DIFFERENTIAL SPECTROPHOTOMETRY. I. Determination of Cadmium With Xylenol Orange. Pasechnova, R. A.; Mokhov, A. A. (Leningrad Technological Inst.). Zh. Anal. Khim.; 27: No. 11, 2146-2151 (Nov 1972). (In Russian).

A method of full differential spectrophotometry is suggested for determining cadmium in the presence of tellurium at a component ratio of 1:1. The method enables the determination of cadmium with the relative error of not more than 0.6%. The cadmium concentration limits in the presence of tellurium (2 to 50 μg/50 ml) within which the Beer's law is obeyed were established. The conditions are defined for the formation of the cadmium complex compound with xylenol orange in a hydrochloric acid applied to the method of full differential spectrophotometry. (auth)

**22142** FLUORIMETRIC DETERMINATION OF IODINE IN THE FORM OF NITRON TRIIODIDE. Gantchev, N.; Kireva, A. (Ecole Normale Superieure, Plovdiv, Bulgaria). Mikrochim. Acta; No. 6, 889-895(1972). (In French).

The compound $NtI_3$ obtained by studying the mutual action of nitron (Nt) and certain halogenated complexes. Its properties were established, also its composition and the mechanism of the formation of the compound. Its properties have served as the base for the elaboration of an extractive method for the colorimetric determination of microquantities of iodine. The method is based on the oxidation of $I^-$ into $IO_3^-$, reduction of the latter through $I^-$ in acidic surroundings and obtaining $I_3^-$, which is then extracted in the form of $NtI_3$ with the aid of $C_2H_4Cl_2$ in the presence of $NtHSO_4$. The method may be employed to advantage in the presence of $SO_4^{2-}$, $Cl^-$, $Br^-$, and $NO_3^-$. This method permits the determination of from 2 to 20 μg of iodine in 25 ml of solution, the coefficient of variation being ±3%. (auth)

**22143** COULOMETRIC TITRATION OF Mo(VI) WITH ELECTROGENERATED Ti(III) USING SPECTROPHOTOMETRIC END POINT DETECTION. Chavdarova, R. D. (Higher Inst. of Chemical Tech., Sofia). Compt. Rend. Acad. Bulg. Sci.; 25: No. 9, 1241-1244(1972).

Optimum conditions for the coulometric titration of Mo(VI) with electrogenerated Ti(III) using spectrophotometric end point detection were established. Molybdenum(VI) solution is introduced in the cathode space of electrolysis cell and a nitrogen stream is passed through the catholyte for 30 min and the temperature is kept constant at 20°C. The photocurrent of the supporting electrolyte is read. Ti(III) is generated for a definite period of time at an appropriate generating current. The photocurrent is read after 2 min, and then a new amount of Ti(III) is generated. The extinctions for all stages of the titration are calculated. The graph of extinction/time is plotted, and the end point is determined. (DHM)

**22144** USE OF HYDROXYLAMINE IN TITRIMETRY. Potentiometric Determination of Periodate in an Alkaline Medium. Norkus, P. K.; Yankauskas, Yu. Yu. (Inst. of Chemistry and Chemical Tech., Vilnyus, USSR). Zh. Anal. Khim.; 27: No. 12, 2421-2423(Dec 1972). (In Russian).

A method was developed for the potentiometric determination of periodate in an alkaline medium by a hydroxylamine solution. A method is suggested for the hydroxylamine solution standardization. (auth)

**22145** USE OF DISTILLATION SEPARATION OF ELEMENTS FOR INCREASING THE SENSITIVITY OF THE SPECTRAL ANALYSIS. Communication 1. Determination of Impurities in Niobium and Tantalum Chemicals of High Purity. Zakhariya, N. F.; Staikov, A. I.; Nazarova, T. F. (Inst. of Inorganic Chemistry, Odessa). Zh. Anal. Khim.; 27: No. 12, 2400-2404(Dec 1972). (In Russian).

Optimum conditions for the spectral determination of 20 impurities in high-pure niobium and tantalum were found from the data on the reaction rate of the distillation separation of elements in the electrode craters in the presence of AgCl or charcoal powder and by using the buffer effect in the arc plasma. The sensitivity of the determination is $10^{-6}$ to $10^{-4}$%. The variation coefficient for a determination is 15% at the concentration corresponding to the detection limit of 30%. (auth)

**22146** SIMULTANEOUS IODIMETRIC DETERMINATION OF MERCURY(II) AND IODIDE IONS. Investigation of the Nessler Reaction. Szasz, G.; Lukacs, V.; Vegh, A. (Semmelweis Medical Univ., Budapest). Acta Pharm. Hung.; 41: No. 5, 227-231(1971). (In Hungarian).

The $I^-$ is oxidized by Cl to $IO_3^-$, in the presence of KCN, and $Hg^{2+}$ is converted into $Hg(CN)_2$. The excess of KCN is then removed with formaldehyde and, with the addition of Br, the $Hg(CN)_2$ is decomposed and CNBr is formed. When $I^-$ is added, both $IO_3^-$ and CNBr liberate iodine, which can be titrated with $Na_2S_2O_3$. The method can be used for the indirect determination of $NH_3$ with Nessler reagent: after filtration and washing, the precipitate is dissolved and its combined $Hg^{2+}$ and $I^-$ content is determined by the method described. (Anal. Abstr.)

**22147** PRECISION OF QUANTITATIVE ANALYSIS METHODS IN SPARK MASS-SPECTROMETRY. Ordzhonikidze, K. G.; Samadashvili, O. A.; Glinskikh, V. M.; Yur'eva, O. K.; Karpenko,

I. K. Zh. Anal. Khim.; 27: No. 12, 2310-2313(Dec 1972). (In Russian).

Methods of the quantitative calculation of the concentration and the preliminary calibration of the emulsion are compared. The comparison is based on the analysis of a Mo matrix for Cr and Fe impurities from the point of view of the reproducibility of the results, rapidity and simplicity of the mass-spectrogram manual treatment. The precision of the analysis varies from 5 up to 50% with respect to the standard deflection depending on the method used. (auth)

**22148** FLAME-PHOTOMETRIC DETERMINATION OF CALCIUM, STRONTIUM, AND BARIUM IN COMPLEX NIOBATES. Shemet, V. V.; Malygina, L. V.; Luft, B. D.; Milyavskii, Yu. S.; Pavel'eva, O. Kh. (Inst. of Radio-Engineering and Electronics, Moscow). Zh. Anal. Khim.; 27: No. 12, 2341-2344(Dec 1972). (In Russian).

The extinguishing effect of niobium on the emission of alkaline earth metals in the acetylene–air flame was found. The mutual effect of Ca and Sr on the emission intensity of the elements in the presence of niobium was studied. Reasons for the extinguishing effect of niobium on the emission intensity of Ca and Sr was investigated by the method of two sprayers. The interaction of Ca and Sr with niobium peroxocomplexes was elucidated by the isomolar series method. A method was developed for the analysis of complex niobate for Ca, Sr and Ba. The sensitivity is 0.08 μg/ml Ca, 0.04 μg/ml Sr, and 1.5 μg/ml Ba. The variation coefficient does not exceed 3%. (auth)

**22149** METHODS FOR CRYSTALLIZATION ANALYTICAL CONCENTRATION OF MICROCOMPONENTS. Communication 5. Concentration of Alkaline Earth Metal Impurities From a Sodium Nitrate Melt. Afanasiadi, L. I.; Blank, A. B.; Zolotovitskaya, E. S.; Yakovenko, E. I. (All Union Scientific-Research Inst. of Monocrystals, Scintillation Materials, and Specially Pure Chemicals, Kharkov). Zh. Anal. Khim.; 27: No. 12, 2345-2348(Dec 1972). (In Russian).

Conditions were studied for concentrating alkaline earth elements and magnesium from a sodium nitrate melt by the method of normal direction crystallization. The effective distribution coefficients of ions between the liquid phase and the melt under conditions used are: 0.5 ± 0.1 (Mg), 0.15 ± 0.05 (Ca), 0.06 ± 0.03 (Sr), and 0.015 ± 0.008 (Ba). The concentration permits a two order increase in the sensitivity of determining alkaline earth metal impurities in sodium nitrate (the determinable minimum for Ca, Sr, and Ba is $2 \times 10^{-5}$, $3 \times 10^{-6}$ and $2 \times 10^{-6}$ weight % respectively). (auth)

**22150** SPECTRAL DETERMINATION OF YTTERBIUM, LANTHANUM, AND YTTRIUM IN ROCKS. Laktionova, N. V.; Ageeva, L. V.; Karyakin, A. V. (Inst. of Geochemistry and Analytical Chemistry, Moscow). Zh. Anal. Khim.; 27: No. 12, 2358-2362(Dec 1972). (In Russian).

A direct spectral method was developed for determining Yb and Y in basic and ultrabasic rocks with the sensitivity of up to $10^{-5}$% and La of up to $10^{-4}$%. A criterion is suggested for estimating the homologenity of the line intensity of the element. The reproducibility, sensitivity, and correctness of the method was estimated. (auth)

**22151** PAPER ELECTROPHORESIS OF METAL IONS IN EDTA LIGAND BUFFER SOLUTIONS. III. Qualitative and Quantitative Analysis of Rare Earth Metal Mixtures. Jokl, V.; Pikulikova, Z. (Comenius Univ., Bratislava). J. Chromatogr.; 74: No. 2, 325-331(20 Dec 1972). (In German).

Electrophoretic analyses of mixtures of rare earth metal ions were carried out in the ligand buffer system $Zn^{2+}-ZnL^{2-}$ (pH 2). The qualitative electrophoretic separation of the complete rare earth mixture by using two ligand buffers (pL values 17.5 and 18.5) was quite satisfactory. The quantitative analyses were performed after detection with alizarine via indirect densitometry. It was possible to determine 1 to 10 μg of the rare earth metal ions, the relative deviation being less than 7.5%. A model mixture, lighter flints, and a rare earth alloy were analyzed. (auth)

**22152** USE OF AZO-AZOXY FMP (4-[2-(2-HYDROXY-5-METHYLPHENYLAZOXY)PHENYLAZO]-3-METHYL-1-PHENYL-2-PYRAZOLIN-5-ONE) FOR THE SEPARATION OF STRONTIUM AND BARIUM BY EXTRACTION. Nadezhda, A. A.; Gorbenko, F. P.; Dunaevskaya, K. A.; Kostrinskaya, L. A. Tr. Vses. Nauch.-Issled. Inst. Khim. Reaktivov; No. 32, 200-203(1970). (In Russian).

Strontium can be separated from large amounts of Ba as the Azo-azoxy FMP complex [used as a 0.02% solution in $CCl_4$–tributyl phosphate (4 : 1)] by extraction from aqueous medium of pH 12.6 to 14 (optimum pH 13). The Sr is extracted quantitatively, but <30% of the Ba is extracted. The Sr is then re-extracted with 0.1 N HCl, and can be determined by complexometric titration or by flame photometry. Washing the organic layer with an alkaline solution, or re-extraction, permits 100 to 200 μg of Sr to be separated from 10 mg of Ba, and by further washings or extractions Sr can be separated from a 500-fold excess of Ba. The extraction and complexometric determination of Sr take 20 to 30 min., and the error is <10%. (Referativnyi Zh.)

**22153** SEPARATION OF STRONTIUM FROM YTTRIUM BY USING AZO AZOXY FMP. Nadezhda, A. A.; Gorbenko, F. P.; Dunaevskaya, K. A.; Zelinskaya, M. I. Tr. Vess. Nauch. Issled. Inst. Khim. Reaktivov; No. 32, 204-207(1970) (In Russian).

The extractant azo-azoxy FMP (4-[2-(2-hydroxy-5-methylphenylazoxy)-phenylazo]-3-methyl-1-phenyl-2-pyrazolin-5-one) can be used to separate Sr from large amounts of Y if aqueous potassium sodium tartrate (I) is added to prevent the hydrolysis of $Y^{3+}$. The presence of I affects the extraction only slightly, and Sr can be extracted quantitatively at pH 13.5 to 14. To determine Sr in the presence of a 300-fold excess of Y, to 15 ml of neutral test solution add 10 ml of 20% aqueous I and 1.5 ml of 20% aqueous NaOH, dilute with water to 25 to 30 ml, and extract with an equal volume of extractant for 1 min. Wash the organic layer with 0.3 N NaOH; alternatively, to the organic phase add 20 ml of 0.1 N HCl and 5 ml of I solution, shake for 1 min. and without separating the phases, add 2 ml of NaOH solution. Re-extract the Sr from the organic phase into 20 ml of 0.1 N HCl, to the aqueous solution add 20 ml of concentrated aqueous $NH_3$, and titrate the Sr with 0.01 N EDTA (methylthymol blue as indicator) until the solution becomes grey. The error is <±10%. (Referativnyi Zh.)

**22154** USE OF MEMBRANES TO INDICATE THE EQUIVALENCE POINT. V. The Parchment Paper Membrane Impregnated With $BaSO_4$ Indicating Electrode in the $Cl^-$, $Br^-$, $I^-$ Titration. Liteanu, C.; Popescu, I. C. (Babes Bolyai Univ., Cluj). Rev. Roum. Chim.; 15: No. 6, 973-985(Jun 1970).

The potential of the parchment-paper membrane impregnated with $BaSO_4$ is affected by the presence of foreign ions others than membranogens, in the contacting solutions. This potential-depressing effect (secondary ionic specificity) characteristic of all the membrane electrodes, was used to the determination of $Br^-$ and $I^-$ by zero current potentiometric titration with $Ag_2SO_4$. In this case the membrane acts as an indicator electrode for $Br^-$ and $I^-$, respectively. The precision of the determinations is satisfactory. (auth)

**22155** AMPEROMETRIC TITRATION OF A MIXTURE OF THORIUM AND BISMUTH WITH EDTA, WITH USE OF A ROTATING TANTALUM ELECTRODE. Zhdanov, A. K.; Markhabaev, I. A. (Tashkent State Univ.). Zh. Vses. Khim. Obshchest. im. D. I. Mendeleeva; 16: No. 5, 585(1971). (In Russian).

The test solution (40 ml), made 0.2N to 0.25N in $HNO_3$ and containing 0.1 to 18 mg each of Bi and Th, is titrated amperometrically (rotating tantalum electrode and S.C.E.) with EDTA solution at –1.2 V to determine Bi. The pH is adjusted to 4 to 5 with 0.5 to 1 g of Na acetate, and the titration is continued at –1.2 V. The total titre corresponds to Bi plus Th, and that for Th is obtained by difference. (Anal. Abstr.)

**22156** DETERMINATION OF EUROPIUM IN CRYSTAL PHOSPHORS BASED ON YTTRIUM ORTHOVANADATE AND YTTRIUM OXIDE. Poluektov, N. S.; Tishchenko, M. A.; Ovchar, L. A. (Inst. of General and Inorganic Chemistry, Odessa). Ind. Lab. (USSR) (Engl. Transl.); 38: No. 4, 535-537(Apr 1972).

Translated from Zavod. Lab.; 38: No. 4, 425-427(Apr 1972).

Absorption spectrophotometric and flame photometric methods were investigated for the determination of Eu in crystal phosphors based on yttrium orthovanadate and yttrium oxide. Absorption spectrophotometry was found to be an accurate method for determining 1 to 10% of europium; the variance coefficient, calculated from 30 determinations, was 1.3%. Accuracy was also high with the flame photometric method; the variance coefficient calculated from 25 determinations was 2.2%. (JGB)

**22157** SPECTROPHOTOMETRIC DETERMINATION OF RUBIDIUM AND CESIUM. Boguslawska, K.; Cyganski, A. (Polytechnikum, Lodz, Poland). Z. Anal. Chem.; 261: No. 4-5, 392 (1972). (In PL).

A method for Rb and Cs determination is based on precipitation of these elements as $M_2Sr[Cu(NO_2)_6]$, dissolution of the precipitate in water, and measurement of the absorption at 350 nm. (MCG)

**22158** ION-EXCHANGE SEPARATION AND SPECTROPHOTOMETRIC DETERMINATION OF MOLYBDENUM AND TUNGSTEN IN RHENIUM METALS. Kuroda, Rokuro; Kawabuchi, Kazuaki (Univ. of Chiba, Japan). Z. Anal. Chem.; 261: No. 4-5, 394-396 (1972).

The adsorbability of Mo(VI), W(VI), and Re(VII) on a weakly basic diethylaminoethylcellulose in chloride media was investigated and an effective procedure for the separation and spectrophotometric determination of traces of Mo and W in Re metals was developed. (MCG)

**22159** REMARKS CONCERNING THE CONTROLLED POTENTIAL COULOMETRIC MEASUREMENTS OF URANIUM IN SAMPLES IN THE 10 MG RANGE. Le Duigou, Y.; Lauer, K. F. (Euratom, Geel, Belgium). Z. Anal. Chem.; 261: No. 4-5, 398-399(1972).

Two sources of systematic errors were found in this method for quantities of 8 to 10 mg U. Chemical standardization of the method, possible errors resulting from preparative chemistry, and systematic errors due to differences in coulometric procedure are discussed. It is recommended that the coulometric titration method be standardized for each new set of measurements on small uranium samples. (MCG)

## *Radiometric and Radiochemical Procedures*

*Refer also to abstracts 22480, 22517, 22762, 22784–22789, 23778, and 23785.*

**22160** (ANL-7960(Pt.2), pp 115-135) DETERMINATION OF LOW-LEVEL AMOUNTS OF $^{228}$Th IN HUMAN BIOLOGICAL MATERIALS BY ELECTROSTATIC COLLECTION OF DECAY PRODUCTS OF $^{220}$Rn. Kuchta, D. R.; Beskid, N. J. Jr. [nd].

Radiological and environmental research division annual report, July 1971– Jun 1972.

Thorium-228 and other members of the thorium decay series are determined indirectly by measuring the alpha-emitting decay products of $^{220}$Rn, the noble gas produced by decay of $^{224}$Ra. An advantage of the method is that the usual detailed and lengthy chemical separation procedures are not necessary. Preliminary ashing and dissolution of biological samples is the only preparation required in order to deemanate $^{220}$Rn from solution. The method consists in deemanation of $^{220}$Rn from solutions, electrostatic collections of $^{216}$Po and $^{212}$Pb on a negatively charged zinc sulfide phosphor-coated electrode disc, and subsequent scintillation counting of the $\alpha$-emitting decay products, $^{212}$Bi and $^{212}$Po. A one-inch photomultiplier tube having a zinc sulfide-coated photocathode serves as the detector. This arrangement provides essentially $4\pi$ geometry for counting. Background levels of these counters are about 0.03 cpm. The overall efficiency of the method varies as a function of flow rate, potential applied to the collecting disc, collection period, and counting period. Optimum conditions were determined by a study of these parameters. Overall efficiency is the ratio of the initial counting rate of $^{212}$Bi and $^{212}$Po which could be deposited and counted after an infinite collection period to the disintegration rate of $^{224}$Ra in solution. Under optimum conditions, the maximum overall efficiency obtainable is $0.31 \pm 0.01$ cpm/dpm $^{224}$Ra for the analysis system described in this paper. This method is simple and applicable to the determination of pCi amounts of $^{228}$Ra, $^{228}$Th, and $^{232}$Th and is of practical importance in determining the amounts of activity in biological samples, particularly in the study of dial painters and other subjects having long-term deposition of $^{228}$Ra. (auth)

**22161** (ANL-7960(Pt.2), pp 171-175) STABILITY OF BACKGROUND AND COUNTING EFFICIENCY FOR RADIUM MEASUREMENTS IN VIVO. Huff, D. R. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Routine measurements of counter background and efficiency for radium gamma rays demonstrate a high degree of stability of both parameters. Observations which deviate more than expected on statistical grounds are explained. (auth)

**22162** (UCRL–73904) IN-SITU MEASUREMENT OF RADIONUCLIDES IN THE ENVIRONMENT WITH A Ge(Li) SPECTROMETER. Anspaugh, L. R.; Phelps, P. L.; Gudiksen, P. H.; Lindeken, C. L.; Huckabay, G. W. (California Univ., Livermore. Lawrence Livermore Lab.). 24 Jan 1973. 50p. (CONF-720805–6). Dep. NTIS $3.50.

From second conference on natural radiation environment; Houston, Texas, USA (7 Aug 1972).

A portable Ge(Li) detector has proven to be a reliable and stable probe of the environmental radiation field, and can be calibrated using point sources and theoretical calculations to provide quantitative data on the presence of any radionuclide in the earth's surface. The method is most accurate when applied to the naturally occurring radionuclides, and also provides limited ability to examine disequilibrium in the $^{238}$U radioactive series. A powerful advantage of the method is that results with the same precision can be obtained in about 0.01 of the time required by soil sampling and conventional laboratory analysis techniques. Results for aged surface-deposited radionuclides are not as accurate due to variations in the soil density and distribution with depth. The primary advantage of the Ge(Li) detector and the semi-theoretical calibration approach is that complex mixtures of many radionuclides can be resolved and quantitated. (auth)

**22163** CONTINUOUS DETECTION OF RADIOACTIVE GAS CHROMATOGRAPHIC EFFLUENTS BY LIQUID SCINTILLATION. Schutte, L.; Koenders, E. B. (Unilever Research Duiven, Zevenaar, Netherlands). J. Chromatogr.; 76: No. 1, 13-20 (7 Feb 1973).

A system for the detection of radioactive effluents from a gas chromatograph is described. The effluents are continuously dissolved in a stream of scintillator solution. After most of the carrier gas is split off, the solution is led at a constant rate through a helical flow cell inserted in a liquid scintillation counter. The main advantages of the system are its expediency for all radioactive compounds, the absence of tailing or memory effects, good resolution, and high sensitivity (less than 0.5 nCi). Peak fractions can be collected after they have passed through the flow cell for accurate activity measurements. The method is also suitable for distinguishing between compounds labeled with two different radioactive isotopes. (auth)

**22164** $^{90}$Sr IN TEETH: A COMPARISON OF METHODS. Rytomaa, I.; Paakkola, O. (Univ. of Helsinki). Acta Odontol. Scand.; 29: No. 3, 321-326(1971).

Strontium-90 activity in teeth was determined by measuring the Cherenkov radiation with a liquid scintillation counter. The results did not differ from those obtained by the radiochemical separation of $^{90}$Sr and measurement of the radioactivity with a low-background $\beta$ counter. The mean $^{90}$Sr content of teeth of cattle in Finland was 20.1 pCi/g Ca. Gamma spectra and x-ray fluorescence analysis indicated that other radionuclides would not interfere in determination of the $^{90}$Sr content using Cherenkov radiation measurements. (HLW)

**22165** METHOD OF COUNTING $^{45}$Ca, IN SAMPLES CONTAINING PHOSPHATE, WITH USE OF THE LIQUID SCINTILLATION SPECTROMETER. Haacke, H.; Wassermann, O. (Christian Albrechts Univ., Kiel). Arzneim.-Forsch.; 22: No. 2, 473(1972). (In German).

For the determination of Ca in muscle tissue, the sample is wet-oxidized and the inorganic residue is dissolved in dilute HCl. When this solution is added to the scintillation fluid (1 ml of ethanol, 5 ml of 1,4-dioxan and 5 ml of a 0.3% solution of 2,5-diphenyloxazole in toluene), the counting yield of $^{45}$Ca diminishes by 5 to 20% during 12 hr, owing to a slow separation of calcium phosphates from the mixture. Reliable results can be obtained either by standardizing the time between preparation and counting of the sample solution or by the addition of a suitable thixotropic gel powder to the sample solution. The latter method gives a counting yield that is stable for several days and does not affect the efficiency. (Anal. Abstr.)

**22166** RAPID METHOD FOR DETERMINATION OF RADIOACTIVE IMPURITIES IN SOLUTIONS OF $^{99m}$Tc. Decombaz, M.; Gostely, J. J.; Lerch, P. (Ecole Polytechnique Federale, Lausanne, Switzerland). Radiochem. Radioanal. Lett.; 13: No. 2, 139-149(5 Mar 1973). (In French).

A lead-covered NaI 3" × 3" detector system associated with a $\gamma$ spectrometer was used to realize the determination of radioactive impurities in $^{99m}$Tc solutions for medical use. The speed of the method allows the preventive detection of $\gamma$-emitting impurities with energy above 300 keV even when half life is near that of $^{99m}$Tc. Sensitivity is better than one ppM for photonic intensity of impurity reported to $^{99m}$Tc. (auth)

**22167** DETERMINATION OF TRACES OF TRITIUM IN $^{3}$He BY LIQUID SCINTILLATION. Lefevre, H. (Commissariat a l'Energie Atomique, Montrouge, France). Radiochem. Radioanal. Lett.; 13: No. 2, 125-137(5 Mar 1973). (In French).

The possibility of determining amounts up to $5 \times 10^{-11}$ vol.% of tritium in helium is demonstrated. The method is based on the liquid scintillation counting of tritiated water formed in situ by the oxidation of tritium on a copper oxide covered filament. (auth)

**22168** RADIOACTIVE KRYPTONATES IN VOLUMETRIC ANALYSIS. XII. End-point Detection by Radioactive Kryptonates of Amalgams. Toelgyessy, J.; Dillinger, P. (Slovak Technical Univ., Bratislava). Radiochem. Radioanal. Lett.; 13: No. 2, 117-124(5 Mar 1973).

A method was developed for the determination of ascorbic acid by redox titration with 0.01 M $FeCl_3$ and using radioactive Kryptonate of Cd amalgam as an indicator. The titration was carried out by the discontinuous method, by measuring the activity of the radioactive Kryptonate. (auth)

**22169** RADIOMETRIC METHOD FOR DETERMINING MOLYBDENUM. II. Determination of Molybdenum in Tungsten by the Radiometric Correction Method Using Preliminary Separation of the Elements. Shamaev, V. I.; Martynov, A. M.; Staroverova, L. L. (Moscow Chemical Technological Inst.). Zh. Anal. Khim.; 27: No. 11, 2260-2262(Nov 1972). (In Russian).

A method was developed for determining molybdenum by radiometric correction method using substoichiometric amounts of EDTA. The preliminary separation of molybdenum with hydrogen sulfide in the presence of tartaric acid is used. (auth)

**22170** CHEMICAL COMPOSITION OF THE LUNAR SURFACE. Turkevich, A. L. (Univ. of Chicago). Accounts Chem. Res.; 6: No. 3, 81-89(Mar 1973).

The $\alpha$ particle technique of chemical analysis is reviewed and the results obtained on the Surveyor missions are reported. The elements determined by $\alpha$ scattering are O, Na, Mg, Al, Si, Ca + K, Ti, and Fe. Results obtained on subsequent missions and conclusions derived therefrom are also presented. (DHM)

**22171** RADIOMETRIC ANALYSIS OF CALCIUM-STRONTIUM MIXTURES WITH SUBSTOICHIOMETRIC SEPARATION. II. Garbauskas, G.; Martynov, A. M.; Kondratenko, A. A.; Shamaev, V. I. Tr. Mosk. Khim.-Tekhnol. Inst.; No. 67, 158-160(1970). (In Russian).

To determine Ca in the presence of Sr in excess, isotopic dilution with $^{45}$Ca is used, with precipitation of the Sr as $SrSO_4$ in the presence of EDTA and subsequent substoichiometric precipitation of Ca as the oxalate. (Referativnyi Zh.)

**22172** OPTIMUM CONDITIONS FOR DILUTION IN THE MULTIPLE ISOTOPE-DILUTION METHOD. Atrashkevich, V. V.; Zimakov, I. E. (Inst. of Physical Chemistry, Moscow). Zh. Anal. Khim.; 27: No. 12, 2302-2309(Dec 1972). (In Russian).

Optimum dilution conditions and analysis errors are discussed for main known modifications of the multiple isotope-dilution method based on the substoichiometric separation principles. A calculation formula $x = m(I_0/I_1-1)$ is identical to $x = m(I_2-I_1)/(BI_1-I_2)$. The dilution of the inactive part of an element to be determined with the radioactive additive by 2 to 5 times is optimum for these cases. A modification of the isotope-dilution method using the $x = m(I_1/I_2-c)$ at $c < 1$ gives the least error in comparison with other versions of multiple isotope dilution. The dependence of the analysis variation coefficient on the degree of the isotope dilution was determined for the version with calculation formula of $x = (I_2m_2-I_1m_2)\ (I_1-I_2)$. Optimum dilution conditions for the modification differ from those for other versions and depend on the ratio of know standard additives $m_1$ and $m_2$. Graphical dependences (v,i) are given for some $m_2/m_1 = c_1$ values which show that the analysis variation coefficient is constant within the more wide dilution range the less the value of $c_1$. (auth)

**22173** TECHNIQUE FOR THE DIRECT COUNTING OF $^{14}$C OR TRITIUM IN BIOLOGICAL FLUIDS. Apelgot, S.; Chemama, R.; Frilley, M. (Institut du Radium, Paris). Rev. Eur. Etud. Clin. Biol.; 17: No. 7, 715-720(Aug 1972).

A technique for measuring the radioactivity ($^{14}$C or $^{3}$H) in urine, the total blood, or the blood plasma is presented. Twenty and 100 mm$^3$ samples of these liquids are put on glass fiber papers, which are then placed directly (wet or dried) in a scintillating medium containing dioxane. Preliminary calibrations and studies of the spectral curves of the scintillations enable the optimum operating conditions to be defined for each case studied. The efficiencies obtained are reproducible and higher than those obtained using classical techniques. As the calibration curves are reproducible, it is not necessary to measure the efficiency for every experiment. No prior treatment is necessary and no stray light effects appear. The results are determined (at the latest) 4 hours after sampling. (France)

**22174** STUDIES OF SOLID SURFACES WITH 100-keV $^4He^+$ AND $H^+$ ION BEAMS. Buck, T. M.; Wheatley, G. H. (Bell Telephone Labs., Inc., Murray Hill, NJ). Surface Sci.; 33: No. 1, 35-55(Oct 1972).

Backscattering of $^4He^+$ and $H^+$ ions incident at 100 keV was used to detect foreign atoms on silicon and graphite surfaces, and also surface disorder on silicon. The ion beams were supplied by an ion-implantation accelerator. Energy spectra of the backscattered ions were measured by an electrostatic analyzer (ESA) which had 3% energy resolution. Foreign-atom sensitivity of this system, expressed as the atom density required to yield 10 counts, is $1.3 \times 10^{12}/cm^2$ for gold, $9 \times 10^{12}/cm^2$ for iron, and $3 \times 10^{14}/cm^2$ for oxygen, at an ion dose of 0.8 $\mu$C per point. Use of an 8-$\mu$C dose lowers these limits an order of magnitude at the expense of greater surface damage and longer measurement time. The effective scattering yield as measured in the ESA departs somewhat from the Rutherford $Z^2$ dependence because of ion neutralization which depends on ion energy which in turn depends on the mass of the target atom. Ion channeling was used to suppress scattering from silicon atoms beneath the surface which tends to obscure the peaks for light elements such as oxygen and carbon. The channeling phenomenon was also used to study surface disorder due to abrasion damage and damage done by the ion beam itself. Sputtering of metal films by the 100-keV $^4He^+$ beam was negligible. However, iodine was removed from silicon surfaces at a detectable rate. This technique at 100 keV, in common with backscattering at higher energies, does not require uhv conditions. It can, therefore, be used in a simple vacuum system to analyze surfaces of technological interest which might be altered by the heating or the heavy-ion bombardment, which are required to remove adsorbed background gas layers in several other surface analytical techniques. (35 references) (auth)

**22175** RADIOMETRIC DETERMINATION OF AgI-TlI-($^{131}$I), AgI-$HgI_2$-($^{131}$I), AND $HgI_2$-TlI-($^{131}$I) SYSTEMS. Despotovic, R.; Despotovic, L. A.; Despotovic, Z.; Filipovic, N.; Grabaric, Z.; Popovic, S. (Ruder Boskovic Inst., Zagreb). Croat. Chem. Acta; 44: No. 3, 341-349(1972).

The principle and procedure for radioanalytical determination of intermolecular interactions in a polycomponent system of solid-liquid: type is described. As models AgI-TlI-($^{131}$I), AgI-$HgI_2$-($^{131}$I), and $HgI_2$-TlI-($^{131}$I) systems were used. The AgI-TlI-($^{131}$I) system was analysed in detail and radioanalytical results obtained were compared using x-ray analysis, conductivity and micro differential thermal analysis. Of the other two systems the results obtained were compared only with the results of x-ray analysis. As all the results obtained agree with literature data, it is concluded that the described radioanalytical method is applicable for adequate analysis of intermolecular interactions in mixed systems. (auth)

### *Separation Procedures*

*Refer also to abstract 22228.*

**22176** (CONF-710847-, pp 227-252) DEVELOPMENT OF A MONITORING FILTER FOR IODINE. Vagslid, Torgeir (Institutt for Atomenergi, Kjeller, Norway). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference, Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

The development of a monitoring filter for iodine involved tests with various types of charcoal and the design and testing of a suitable filter cartridge. An attempt was made to obtain an absolute measurement of the filter efficiency by comparing the accumulated $^{131}$I activity on the charcoal filter with measurements of $^{131}$I in air samples taken with vacuum jars. This method allowed determination of the filter efficiency under the varying operating conditions normally encountered in practice at nuclear plants. The type of filter developed as a result, and about 1½ years' operational experience with it, is also described. (auth)

**22177** (IAE-2126) MOLECULAR-STATISTICAL APPROACH TO THE INVESTIGATION OF EXTRACTION EQUILIBRIA. Chudinov, E. G. (Gosudarstvennyi Komitet Po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Atomnoi Energii). 1971. 28p. (In Russian).

INIS.

The critical choice of a molecular-statistic model of extraction reactions was proposed by Komarov and Shpunt. On the basis of this model calculations of extraction equilibria were conducted, using trivalent actinide elements by trialkylammonium nitrates. The model adequately computed the effect of molecular dimensions and symmetry of the extractant. The range of application of the model is limited only by those conditions under which the empirical parameters of the equation were chosen. Further, the model separated the effects of steric and induction factors on the distribution coefficients and separation factors of selected pairs of elements. In the case of separating trivalent actinide elements by alkylammonium nitrate extraction, the effect of molecular structure of the extractant was associated chiefly with the induction effect. (tr-auth)

**22178** (IS-T-558) PREDICTIVE CONTROL OF A MIXER-SETTLER EXTRACTOR SEPARATING THE RARE-EARTHS. Seemann, R. C. (Ames Lab., Iowa). Feb 1973. Contract W-7405-eng-82. 88p. Dep. NTIS $6.50.

Thesis.

This study was concerned with the determination of a predictive control model for a mixer-settler extractor using the dynamic simulation of the extractor. The simulation incorporated the actual equilibrium relationships for a rare-earth system (cerium, neodymium, and samarium), and it accounted for transport delays in an extractor by including first order time lags for flow changes. The simulation was used both for determining steady state operating conditions and for obtaining dynamic responses of the extractor as well as using it as a stand-in for the real extractor in the predictive control studies. In the predictive control work the control variable was solvent flow rate, and the output variables that were controlled were samarium purity in the extract and samarium recovery. The predictive control model consisted of three distinct terms. The first was a steady state gain term, which gave the final steady state value of the control variable for a measured input change. The dynamic compensation term was included in those cases where transients in the output variable resulting from using only a steady state gain term were larger than desired. The final term was a feedback trimmer, which was used to eliminate any final offset in the output variable that might result after an upset because of inaccuracies in the linear steady state gain term. The feed to the extractor was $CeCl_3-NdCl_3-SmCl_3-HCl-H_2O$. The solvent was di- (2-ethylhexyl) phosphoric acid, D2EHPA, in Amsco Odorless Mineral Spirits. The extraction separated samarium into the extract stream and cerium and neodymium into the raffinate stream. (JGB)

**22179** ELUTION BEHAVIOUR OF THE RARE EARTH ELEMENTS ON A MIXED ION-EXCHANGE COLUMN. Yamabe, T.; Hayashi, T. (Tokyo Univ.). J. Chromatogr.; 76: No. 1, 213-220(7 Feb 1973).

The separation of all fourteen rare earth elements was achieved in 4h by using mixed ion-exchange columns. The elution behaviour of the rare earth elements in single and mixed columns is discussed. (auth)

**22180** LIQUID–LIQUID EXTRACTION BY ALKYL PHOSPHORIC ESTERS. I. Extraction of Yttrium by di-(2-ethylhexyl)phosphoric Acid. Brunisholz, G.; Hirsbrunner, W.; Roulet, R. (Univ., Lausanne, Switzerland). Helv. Chim. Acta; 55: No. 8, 2947-2955(11 Dec 1972). (In French).

The extraction of macro-amounts of yttrium from solutions of nitric and perchloric acids by di-(2-ethylhexyl) phosphoric acid was studied. The extraction of yttrium is more effective from the perchloric medium and takes place by two mechanisms: an ion exchange reaction $Y^{3+}/H^+$ at low concentrations and a solvation reaction at high concentrations of yttrium. The stability constant of the mononitratocomplex $YNO_3^{2+}$ was estimated. (auth)

**22181** LIQUID–LIQUID EXTRACTION BY ALKYL PHOSPHORIC ESTERS. II. Extraction of Nitrates of Beryllium and Other Alkaline Earths by Tri-n-butyl Phosphate. Brunisholz, G.; Hirsbrunner, W.; Aerny, J. (Univ., Lausanne, Switzerland). Helv. Chim. Acta; 55: No. 8, 2956-2961(11 Dec 1972). (In French).

The solvent extraction systems $Be(NO_3)_2-HNO_3-H_2O-TBP$/kerosene and $M(NO_3)_2-H_2O-TBP$/kerosene (TBP = tri-n-butylphosphate, M = Be, Mg, Ca, and Sr) were studied. The alkaline earths elements are poorly extracted. Only very high acidities allow better extraction of beryllium. The sequence of extraction of the alkaline earths elements by the TBP depends on the concentration of the cations and is Ca > Be > Sr > Mg if the metal concentration is lower than 2 M. (auth)

**22182** THIN-LAYER CHROMATOGRAPHIC SEPARATION OF TRANSITION-METAL 2-THENOYLTRIFLUOROACETONE CHELATES. Johri, K. N.; Bakshi, K. (Univ. of Delhi). Chromatographia; 5: No. 5, 309-310(1972).

The chelates of Fe(III), Cu(II), Mn(II), Ni(II) and Co(II) were prepared by adding an excess of 10% ethanolic 2-thenoyltrifluoroacetone (I) to the metal acetates in solution at pH 7.5. The precipitates were centrifuged, washed with hot $H_2O$ and extracted with ethyl methyl ketone. Aqueous solutions of mixtures of Ce(IV), Th(IV), Fe(III), and U(VI) were adjusted to pH 4.5 and were extracted with 0.15 M I solution in benzene. Separations were carried out on layers of Fe-free Silica gel G with ethyl methyl ketone or acetone plus a hydrocarbon, e.g., benzene (6 : 1), or isobutyl methyl ketone–xylene (1 : 8) as solvent for the respective groups of elements. The spray reagents used were 0.05 M aqueous $K_2CS_3$, 1% salicylaldoxime solution in ethanol–$H_2O$ (1 : 19), or 1% ethanolic quercetin or 8-hydroxyquinoline. Some chromatograms were also examined under uv radiation. (Anal. Abstr.)

**22183** METHOD FOR THE SEPARATION OF RADIOACTIVE IMPURITIES FROM ZIRCONIUM DIOXIDE. Brugger, W. (to Goldschmidt (Th) AG). German Patent 2,051,299. Apr 1972. 9p. (In German).

A process is proposed for the separation of radioactive thorium and uranium compounds from $ZrO_2$, which is produced by acid treatment or partial chlorination of ground baddeleyite. The contaminating materials are bound by chemisorption to colloidal zirconium oxide hydrate, which is generated "in situ" in a suspension of $ZrO_2$ and can easily be separated from it by decantation. (RB)

**22184** EXTRACTION OF TERVALENT METAL IONS BY ALKYLAMMONIUM SALTS. Mueller, W. (European Inst. for Transurane, Karlsruhe, Ger.). Chem.-Ztg., Chem. App.; 95: No. 11, 499-507(1971). (In German).

The extraction of Fe(III), lanthanoids, and actinoids from $Cl^-$ media by means of long-chain amines (e.g., trilaurylamine) is reviewed. Applications to the determination of Fe, group separations of the lanthanoids and actinoids, separation of the actinoids into two fractions, and the extraction–chromatographic separation of Cm and Am are included. (42 references.) (Anal Abstr.)

**22185** STUDIES OF THE COMPLEXES Th–ALIZARIN AND Th–QUINALIZARIN THROUGH EXTRACTION USING BUTANOL-1. Dragulescu, C.; Simonescu, T.; Nemes, G.; Totan, M. Rev. Roum. Chim.; 15: No. 4, 563-571(Apr 1970). (In German).

Optimal conditions are given for thorium extraction using alizarin and quinalizarin solutions in butanol in the presence of trichloracetic acid. The two complexes were studied in the butanol medium and their composition was determined. Calculated were the stability constants for ThA as $5.8 \times 10^4$ and for ThQuA as $2.68 \times 10^5$. In addition, the influence of several foreign ions was examined. (tr-auth)

**22186** INFLUENCE OF TRICHLORACETIC ACID ON THORIUM EXTRACTION FROM AQUEOUS SOLUTIONS USING BUTANOL-1. Fisel, S.; Nemes, G.; Totan, M.; Simonescu, T. (Univ., Iasi). Rev. Roum. Chim.; 15: No. 7, 1043-1047(Jul 1970). (In German).

The influence of trichloracetic acid on thorium extraction from aqueous solutions with 1-butanol was clarified. It was determined that the probable formula for the extract compound is $[Th(OH)_2A_2]_0$. Moreover, the trichloracetic acid displayed a salt effect as shown by the enhancement of the extraction with increasing amounts of acid. (tr-auth)

**22187** METHOD FOR THE SEPARATION OF PLUTONIUM. Golliher, W. R.; Harris, R. L.; LeDoux, R. A. Jr. (to United States Atomic Energy Commission). German Patent 2,151,722. 27 Apr 1972. 6p. (In German).

A method for the separation of Pu from a mixture of uranium hexafluoride and plutonium hexafluoride is given. The gas mixture is brought into contact with a bed of granular cobalt fluoride at a temperature of 93 to 204°C where the $PuF_6$ is reduced to $PuF_4$ and adsorbed. Consecutive treatment with fluorine gas at temperatures between 371 and 482°C converts the $PuF_4$ back to $PuF_6$ thus enabling it to be separated from the adsorbent. (GF)

**22188** SYNERGISTIC EXTRACTION OF URANYL ION WITH $\beta$-DIKETONES AND SULPHOXIDES. Subramanian, M. S.; Pai, S. A. (Bhabha Atomic Research Centre, Bombay). Aust. J. Chem.; 26: No. 1, 77-83(Jan 1973).

Distribution measurements of the synergistic extraction of uranyl ion with $\beta$-diketones and sulphoxide donors indicate that the long-chain aliphatic sulphoxides are ten times more powerful as synergists than the aromatic sulphoxides. Methods of estimating the relative base strength of the donors by ii and NMR studies of the donor hydrates are described and the results were correlated with the equilibrium constant of the synergistic reaction. For a given sulphoxide donor, the synergistic enhancement seems to be affected by the various substituents changing the acidity of the $\beta$-diketone. From the values of enthalpy and entropy factors derived for these systems by distribution measurements at different temperatures, the greater stability of the complexes with aliphatic sulphoxide donors has been attributed to the entropy factor. (auth)

**22189** ION-EXCHANGE PROCESSES OF SOME TRIVALENT ELEMENTS ON AMORPHOUS ZIRCONIUM PHOSPHATE UP TO 250°C. Ruvarac, A. L.; Marijanac, V. D. (Boris Kidric Inst., Belgrade). J. Chromatogr.; 76: No. 1, 221-228(7 Feb 1973).

The effect of temperature in the range 25 to 250°C on the distribution of trace amounts of radioactive $Eu^{3+}$, $Ce^{3+}$, and $Fe^{3+}$ on amorphous zirconium phosphate, and also the effect of nitric acid concentration, were studied. The experiments were carried out at 25, 50, 110, 150, 200 and 250°C. With increasing temperature, the distribution of the trace amounts of $Eu^{3+}$ and $Ce^{3+}$ increased very slightly, while the increase in the distribution of $Fe^{3+}$ was greater. Furthermore, it was concluded that the reactions investigated are endothermic. These distribution data were used for the calculation of the thermodynamic equilibrium constants and other thermodynamic data. (auth)

**22190** ION ASSOCIATES OF INDIUM AND YTTRIUM WITH XYLENOL ORANGE AND DIPHENYLGUANIDINE. Beschetnova, E. T.; Malinovskaya, L. N.; Golovina, A. P.; Zorov, N. B. (Daghestan State Univ., USSR). Zh. Anal. Khim.; 27: No. 11, 2152-2155(Nov 1972). (In Russian).

The formation and solvent extraction of indium and yttrium with xylenol orange (XO) and diphenylguanidine (DPG) were studied. The molar extinction coefficients of the compounds are $1.2 \times 10^4$ for indium and $6.25 \times 10^4$ for yttrium. The molar ratio of the components is Me : XO : DPG = 1 : 1 : 2. (auth)

**22191** MIXED COMPOUNDS OF NIOBIUM(V) WITH N-PHENYLACETYLHYDROXAMIC ACID, THIOCYANATE, AND PYROCATECHOL. Gibalo, I. M.; Voskov, V. S.; Kamenev, V. F.; Lobanov, F. I. (Moscow State Univ.). Zh. Anal. Khim.; 27: No. 12, 2405-2408(Dec 1972). (In Russian).

The extraction of niobium with solutions of N-phenylacetylhydroxamic acid (PAHA) in benzene and chloroform was studied. The dissociation constant of PAHA was determined ($pK_{HA} = 8.81 \pm 0.08$). The partition constants between benzene and water, chloroform and water were found. The niobium N-phenylacetylhydroxaminate formed is extracted by 92 to 95% from 10 to 11 M HCl. The molar extinction coefficient of the complex in benzene extracts is $\epsilon_{370} = 9800$. Three-component complex compounds are formed in the presence of $SCN^-$ and pyrocatechol. The component ratios are Nb : PAHA : CNS = 1 : 2 : 3 and Nb : PAHA : PC = 1 : 2 : 2. Maximum absorption of benzene extracts is located at 370 nm, the molar extinction coefficients are $3.4 \times 10^4$ and $1.2 \times 10^4$ respectively. (auth)

**22192** USE OF N-CINNAMOYLPHENYLHYDROXYLAMINE IN ANALYTICAL CHEMISTRY. Communication 7. Separation of titanium and zirconium from rare earth elements, yttrium, and scandium. Ostroumov, E. A.; Kulumbegashvili, V. A. (Inst. of Oceanology, Moscow). Zh. Anal. Khim.; 27: No. 12, 2377-2381 (Dec 1972). (In Russian).

Conditions for the precipitation of titanium and zirconium with N-cinnamoylphenylhydroxylamine in the presence of rare earths, yttrium, and scandium were studied. A method was developed for the separation of titanium and zirconium from the elements enumerated. It allows the complete separation using one precipitation. (auth)

**22193** SOLVENT EXTRACTION OF ACTINIDE AND LANTHANIDE ELEMENTS BY QUARTERNARY AMMONIUM SALTS. III. Extraction of lanthanide and transplutonium elements in the systems CTMAB–$LiNO_3$ AND CPB–$LiNO_3$. Szeglowski, Z. (Inst. of Nuclear Physics, Krakow); Mikulski, J.; Gavrilov, K. A.; Kim Yun Bon; Om San Ik Nukleonika; 17: No. 12, 631-637(1972). (In Russian).

The extraction of light rare earth elements, americium, and curium from solutions of lithium nitrate in 0.01 N nitric acid, by means of solutions of cetyltrimethylammonium bromide and cetylpyridinium bromide in chloroform was studied. It was found that the distribution coefficients of lanthanide elements increase linearly with the concentration of lithium nitrate. The values of the coefficients decrease with increasing atomic number. The solvation number of light lanthanides and the separation factors for adjoining pairs of elements were determined. The solvation number for all examined elements are equal to about 2. The separation factors for pairs Pm–Sm, Sm–Eu and Am–Cm are >2. (auth)

**22194** EXTRACTION OF YTTRIUM(III) AND LANTHANUM(III) FROM HYDROCHLORIC ACID SOLUTIONS BY DI-(2-ETHYLHEXYL) PHOSPHORIC ACID. Sato, T.; Ueda, M. (Shizuoka Univ., Hamamatsu, Japan). J. Inorg. Nucl. Chem.; 35: No. 3, 1003-1010 (Mar 1973).

The partition of yttrium(III) and lanthanum(III) between hydrochloric acid solutions and solutions of di-(2-ethylhexyl)phosphoric acid (HDEHP) in kerosene was investigated under different conditions. Infrared and high-resolution NMR spectral studies were carried out for the organic phases. The mechanism of the extraction is discussed on the basis of the results obtained. (auth)

**22195** INFLUENCE OF PULSED AND REVERSING CURRENT ON PURIFICATION OF ZIRCONIUM FROM HAFNIUM DURING THE ELECTROLYSIS OF CHLORINE–FLUORINE MELTS. Petenev, O. S.; Ivanovskii, L. E. Tr. Inst. Elektrokhim., Akad. Nauk SSSR, Ural. Filial; No. 17, 127-130(1971). (In Russian).

The separation of Zr and Hf by the electrolysis of molten chloride/fluoride salts was studied at 700 to 1,000°C by comparing yields of the metal under conditions of constant, pulsed, and reversing currents. Pulsed or reversing currents produced Zr metal containing significantly less Hf than in the case of constant current, and improved the separation coefficient by 3 to 4 times. Anodic dissolution of metallic Zr containing Hf was also studied in a KCl–NaCl–NaF mixture at 800°C. (KSW)

# Inorganic, Organic, and Physical Chemistry

## *Chemical and Physicochemical Properties*

*Refer also to abstracts 22278, 22837, 22858, and 22861.*

**22196** (ANL-7978) CHEMICAL ENGINEERING DIVISION PHYSICAL INORGANIC CHEMISTRY SEMIANNUAL REPORT, JULY–DECEMBER 1972. Blander, M.; Cunningham, P. T.; Eberhart, J. G.; Feder, H. M.; Maroni, V. A.; Schnyders, H. C.; Veleckis, E.; Levenson, M.; Vogel, R. C. (Argonne National Lab., Ill.). Jan 1973. Contract W-31-109-eng-38. 34p. Dep. NTIS $4.00.

Tensimetric measurements of six pressure-composition isotherms in the Li–LiH system were completed at temperatures from 710 to 903°C. Gravimetric studies of this system are in accord with the tensimetric results. The measured temperature at the limits of superheat of three hydrocarbons, methanol, and ethanol is close to 0.9 of the critical temperature. Laser Raman spectra of $PbCl_2$ and $BiBr_3$ vapors are reported. Measurements on phase equilibria in the Li–Te binary system were completed. Measurements and calculations of the insolubility of MgO in $CaCl_2$ are given, and theoretical calculations of phase diagrams of simple reciprocal systems are compared with published measurements. A method for calculating non-empirical pair potentials was successfully applied to calculating properties of H, He, and Ar. Measurements of the subcooling of molten enstatite droplets were made for comparison with meteoritic spherules (chondrules). Theoretical calculations of condensation from a solar nebula indicate that meteorites may be a simple accretion of "primordial dust." (auth)

**22197** (LIB/Trans-489) SOLUBILITY OF COBALT COMPOUNDS IN BOILING WATER AT 185 ATMOSPHERES. Mingulina, E. I.; Martynova, O. I.; Reznikov, M. I. Translated by P. Pakalns from Tr. Mosk. Energ. Inst.; 48: 227-236(1963). 10p. Dep. NTIS (U. S. Sales Only) $3.00.

Investigations were made of the solubility of cobalt compounds in boiling water in primary loops of nuclear power plants using boiling water as the coolant. The solubility of $Co(OH)_2$ in water boiling at 185 atm was studied. At pH 8.5 formation of the $Co(OA)_2$ precipitate began. The undissociated $Co(OH)_2$ molecules amounted to $\sim 5.5 \times 10^3$ mg Co/l. At pH 8.5 and a $Cl^-$ content of 0.52 mg/l, the solid phase consists of basic cobalt salts. The solubility of the cobalt compounds is many times higher than the solubility of pure $Co(OH)_2$. (MCG)

**22198** (SU-326-P-6-X-5) FINAL TECHNICAL REPORT OF RESEARCH. Taube, H. (Stanford Univ., Calif. Dept. of Chemistry). 3 Apr 1972. Contract AT(04-3)-326. 21p. Dep. NTIS.

**22199** MEASUREMENT OF THE WATER VAPOR PERMEABILITY OF FILMS. Gilde, S. A.; Sirokman, F.; Hajdu, E. (Attila Jozsef Univ., Szeged). Acta Univ. Szeged., Acta Phys. Chem.; 18: No. 1-2, 59-62(1972).

A method was developed for the measurement of the water vapor permeability of various types of film. The amounts of water diffusing through were determined in a system of constant vapor content by using $H_2O$ labeled with $^3H$ and by measuring the activities. The method was used to determine the water vapor permeabilities (WVP) of various films. In the case of different thicknesses it was possible to determine characteristic values of the permeability constant (PC) for the individual films. The method is suitable for the comparative characterization of various paint films and protective coatings. (auth)

**22200** TERMOKHIMIYA SOEDINENII REDKOZEMEL'NYKH I AKTINOIDNYKH ELEMENTOV. (Thermochemistry of Compounds of Rare Earth and Actinide Elements). Krestov, G. A. Moscow; Atomizdat (1972). 264p.

This book focuses attention on the thermodynamic properties of the rare earth elements and the actinides, their compounds and their aqueous solutions: enthalpies and entropies of formation, specific heats, and related characteristics. The temperature coefficients of interionic distances and ion radii, thermal expansion of crystalline compounds, and thermodynamic data on the processes of ionization, hydration, dissolution, and phase changes of compounds of the lanthanides and actinides are presented in detail. 310 references. (KSW)

**22201** DIFFUSION OF EUROPIUM(III) IN DI-(2-ETHYLHEXYL)PHOSPHORIC ACID IN TOLUENE-HYDROCHLORIC ACID SYSTEMS WITH AND WITHOUT PHASE TRANSFER. Lyle, S. J.; Smith, D. B. (Kent Univ., Canterbury, Eng.). J. Inorg. Nucl. Chem.; 35: No. 4, 1380-1383(Apr 1973).

The capillary-submersion method (Anderson et al., J. Chem. Soc.; S381(1949)) has been widely employed for the determination of diffusion coefficients in liquids. Measurements described by Bosholm and Pippel (Z. Phys. Chem.; 227: 217(1964)) relate to the diffusion of europium(III) in toluene solutions of di-(2-ethylhexyl)phosphoric acid (HDEHP) and to its diffusion from HDEHP in toluene into aqueous hydrochloric acid. Diffusion coefficients from the former study when plotted against HDEHP concentration gave a curve having certain interesting but not readily explicable features. In order to evaluate the capillary method for further studies of this kind some of the measurements reported by Bosholm and Pippel were repeated. The results obtained are presented and compared with the previously published values with which they are somewhat at variance. (auth)

## Isotope Effects

*Refer also to abstracts 22242, 22279, and 22667.*

**22202** PROCESS FOR PRECIPITATION OF METAL-CONTAINING COMPOUNDS AS DISPERSED GEL PARTICLES IN AQUEOUS PHASE. Grimes, J. H.; Scott, K. T. B.; MacKenna, N. J. (to United Kingdom Atomic Energy Authority). German Patent 2,142,645. 2 Mar 1972. 42p. (In German).

A process is described for precipitation of a metal (actinide and others) compound from a salt solution or an aqueous sol of the metal in gel particle phase that is dispersed in an aqueous phase. A water soluble polymer is added to the solution or sol so that it forms a complex with the metal ions present in the solution or sol. The amount of polymer must be sufficient to form a viscous mixture. The polymer must exhibit a plurality and consist of polysaccharides (dextrane, galcatomannan gums, modified starch and substituted cellulose compounds) and/or poly alcohols (preferably polyvinyl alcohol). A precipitating reagent, alkali or acid, is gradually added to the viscous mixture, precipitating out the compound from the solution or sol while the mixture is being stirred in order to avoid solidification of the precipitate. The concentrations of the metal solution or sol, of the polymer in solution, and of the precipitating reagent are chosen in such amounts and proportions so that the precipitate is formed as a gel particle phase, dispersed in an aqueous phase and not as a continuous gel phase. (GF)

**22203** MECHANISTIC INFERENCES FROM DEUTERIUM ISOTOPE EFFECTS ON COMPETING METASTABLE DECOMPOSITIONS OF ORGANIC IONS. Howe, I.; Uccella, N. A.; Williams, D. H. (Cambridge Univ., Eng.). J. Chem. Soc., Perkin Trans., II; No. 1, 76-80(1973).

Substantial changes in relative abundances of competing metastable transitions from organic ions in the mass spectrometer are shown to occur in certain cases on partial or complete deuteration. In the case of benzene, primary isotope effects occur on loss of H and $H_2$ from the molecular ion. The occurrence of a primary isotope effect on the loss of Cl from the molecular ion of p-chloroethylbenzene is demonstrated by this method and this isotope effect strongly implicates a rearrangement (probably to a 7-membered-ring isomer) before loss of Cl. A quasi-equilibrium theory calculation is carried out to illustrate that a change in relative metastable abundance by a factor of 2.4 is consistent with a primary isotope effect upon one of the reactions. A rearrangement is also inferred from isotope-effect data for the elimination of Br from p-bromoethylbenzene. (auth)

**22204** ADDITIVITY OF CONTRIBUTIONS TO SECONDARY DEUTERIUM KINETIC ISOTOPE EFFECTS AND THEIR ARRHENIUS PREEXPONENTIAL FACTORS. Toward a Method of Fitting Model Calculations to Experimental Data. Schneider, M. E.; Stern, M. J. (Yeshiva Univ., New York). Contract AT(11-1)-3582. J. Amer. Chem. Soc.; 95: No. 5, 1355-1365 (7 Mar 1973).

The quantum secondary deuterium kinetic isotope effects due to individual force-constant changes, between reactant and transition state in a properly constructed model reaction, are, after accounting for a small easily determined correction factor, additive within the limits of usual experimental errors. A similar additivity relationship is found to be valid for the Arrhenius intercepts of the calculated isotope effects. These additivity relationships are used as the basis of a proposed systematic method of fitting model calculations to experimental data for purposes of reaction mechanism elucidation. (auth)

**22205** SECONDARY DEUTERIUM ISOTOPE EFFECTS ON THE THE TRANSFER OF TRIPLET EXCITATION. Caldwell, R. A.; Sovocool, G. W.; Peresie, R. J. (Cornell Univ., Ithaca, NY). J. Amer. Chem. Soc.; 95: No. 5, 1496-1502(7 Mar 1973).

Secondary deuterium isotope effects are shown to be a useful mechanistic tool in the study of triplet excited state reactions. The cis-trans isomerization of $\beta$-methylstyrene photosensitized by various sensitizers is shown to involve transfer of triplet excitation. Isotope effects on the reaction are significant; they depend on the position of deuterium and to some extent on the geometry of the olefin. The results indicate vertical excitation transfer to the trans isomer and imply nonvertical excitation transfer to the cis isomer, invariant to the type of sensitizer in the triplet energy range of 53 to 57 kcal/mol. The implications of these results for photochemical mechanistic studies are discussed. A tentative model for olefin-sensitizer interaction in nonvertical excitation transfer is presented. (auth)

**22206** INTRAMOLECULAR CATALYSIS AND THE INVOLVEMENT OF TETRAHEDRAL INTERMEDIATE PARTITIONING IN THE HYDROLYSIS OF BENZOYLCHOLINE, BENZOYLTHIONOCHOLINE, AND THEIR DIMETHYLAMINO ANALOGS. Bruice, P. Y.; Mautner, H. G. (Yale Univ., New Haven). J. Amer. Chem. Soc.; 95: No. 5, 1582-1586(7 Mar 1973).

The rates of hydrolysis of benzoylcholine, thionobenzoylcholine, and their dimethylamino analogs were measured at 25°C in aqueous buffered solutions in the pH range 7 to 14. The distribution of products obtained in the hydrolysis of the thiono esters is pH dependent; benzoic acid is obtained below pH 9.5 and thiobenzoic acid above pH 11. In moderately basic solutions the tertiary amino esters hydrolyze considerably more rapidly than the corresponding quaternary amino esters. Deuterium isotope effects, product distribution curves and hydrogen bonding considerations indicate that the rate enhancement is due to intramolecular general base-catalyzed water attack on the carbonyl carbon by the unprotonated ester amino group. In strongly basic solutions (pH > 11), the quaternary amino esters hydrolyze more rapidly than their tertiary amino analogs. This is attributed to the differences in pK's of the leaving groups and to electrostatic interactions between the positive charge on the nitrogen and the developing negative charge on the carbonyl heteroatom which result in transition state stabilization. (auth)

**22207** KINETICS, MECHANISM, AND ISOTOPE RATE EFFECT OF THE BASE-CATALYZED FORMATION OF 1-HALOALKYNES FROM ACETYLENES AND SODIUM HYPOHALITES. Lii, R. R.; Miller, S. I. (Illinois Inst. of Tech., Chicago). J. Amer. Chem. Soc.; 95: No. 5, 1602-1611(7 Mar 1973).

The formation of 1-haloalkynes in water at pH > 11 and $[OH^-] > 2[X_2]$ follows third-order kinetics, $v_f = k_f[RC \equiv CH][OH^-][OX^-]$. The solvent isotope rate effects for the chlorination at 46.1°C and bromination at 27.5°C of phenylacetylene are essentially absent, i.e., $k^{H_2O}_{CH}/k^{D_2O}_{CD} = 1.01$ and 1.07(±0.04), respectively. For chlorination of phenylacetylene at 25.3°C, $k = 9.5 \times 10^{-4}\ M^{-2}\ sec^{-1}$, $\Delta H^{+} = 13.0$ kcal/mol, and $\Delta S^{+} = -27$ eu. For bromination of four para-substituted phenylacetylenes (H, Cl, Br, and $CH_3$), $\Delta H^{+} =$ 7.5 to 8.7 kcal/mol and $-\Delta S^{+} =$ 26 to 28 eu; Hammett $\rho$ values for this group were 0.72, 0.77, and 0.825 at 35.3, 25.3, and 15.3°, respectively, and the rate constants ($M^{-2}\ sec^{-1}$) depend on temperature and Hammett $\sigma$ as follows: $\log k = -1.135\sigma - 1893/T + 574\sigma/T + 7.4$. Positive and specific salt effects on the rate of chlorination and on the activity coefficient of phenylacetylene were noted. Toward phenylacetylene, the reactivity of hypohalite is in the order $IO^- > BrO^- \gg ClO^-$. Rates of chlorination and bromination of an alkylacetylene, 3-methylbut-1-yn-3-ol, are within a factor of 5 to 10 of those for phenylacetylene. It is proposed that the mechanism of halogenation involves a fast pre-equilibrium to form $RC \equiv C^-$, a rate-determining step of this anion and hypohalite to yield the intermediate $RC \equiv CXO^{2-}$, and a rapid reaction of this intermediate with water to produce 1-haloalkyne and two hydroxide ions. One consequence of this mechanism is that the reverse process, 1-dehalogenation, probably has the form $v_r = k_r[RC \equiv CX] \cdot [OH^-]^2$, or its equivalent. In exploring the dehalogenation process, we found a rather different route with arsenious oxide; that is, the rate law is $v = K[C_6H_5C \equiv CBr][As_2O_3][OH^-]^2$. The general significance in the area of positive halogen chemistry is indicated. (auth)

**22208** NORMAL VIBRATIONS AND FAR-INFRARED SPECTRA OF AMMONIUM CHLORIDE AND AMMONIUM CHLORIDE-$d_4$ CRYSTALS. Fukushima, K.; Yamamoto, H. (Shizuoka Univ., Japan). Bull. Chem. Soc. Jap.; 45: No. 10, 3058-3064(Oct 1972).

The normal coordinate treatment of optically active lattice vibrations of ammonium chloride and ammonium chloride-$d_4$ at low temperature was made in order to elucidate the nature of the vibrations and obtain force constants in the potential in the crystals by the method of least squares. Using the constants, the optically active lattice vibrations of a crystal model for ammonium chloride and ammonium chloride-$d_4$ at room temperature were calculated. The far-infrared spectra obtained and the Raman and infrared spectra in literature are discussed. (auth)

**22209** HYDROGEN-TRANSFER REACTION BETWEEN KETONES AND ALCOHOLS OVER METAL OXIDE CATALYSTS. Okamoto, Y.; Imanaka, T.; Teranishi, S. (Osaka Univ.). Bull. Chem. Soc. Jap.; 45: No. 10, 3207-3208(Oct 1972).

The mechanism of hydrogen-transfer reactions between methyl ethyl ketone and several alcohols over metal oxide catalysts was studied using a conventional pulse reactor at 260°C. The metal oxides used were MgO, CaO, SrO, and BaO. The kinetic isotope effect for the transfer reactions between methyl ethyl ketone and deuterated alcohols over MgO was found to be 1.04 for $C_2H_5OD$ and 0.722 for $CD_3OD$. (JGB)

**22210** MOLECULAR VIBRATIONS, CONFORMATIONAL ANALYSES, AND FORCE FIELDS OF NORMAL AND MONO-DEUTERATED (METHYLTHIO)METHANETHIOL. Ohsaku, M.; Shiro, Y.; Murata, H. (Hiroshima Univ.). Bull. Chem. Soc. Jap.; 45: No. 10, 3035-3048(Oct 1972).

(Methylthio)methanethiol, $CH_3SCH_2SH$, and (methylthio)methanethiol-$d_1$, $CH_3SCH_2SD$, were prepared, and their ir spectra were obtained in the gaseous, liquid, and solid states. The obtained spectra were assigned. The frequency shifts by D-substitution, gaseous-liquid transition, and liquid-solid transition were also discussed. The normal coordinates of these thiols were treated by a modified Urey-Bradley force field. The force constants used in the computation were transferred from those previously reported, but were adjusted to produce the experimental wave numbers. The calculated wave numbers correspond well with those observed. The stable molecular conformations of the normal and deuterated species were determined by the aid of the normal coordinate treatment. In the gaseous and liquid states, at least three to four forms from among the various structures and conformations were confirmed to exist. In the solid state, though, $CH_3SCH_2SH$ or $CH_3SCH_2SD$ exists in only one form. (auth)

**22211** OXYGEN ISOTOPE EXCHANGE OVER NICKEL OXIDE. Semin, G. L.; Cherkashin, A. E.; Keier, N. P. (Inst. of Catalysis, Novosibirsk, USSR). Kinet. Katal.; 13: No. 6, 1463-1468(1972). (In Russian).

The homomolecular and heteroexchange of oxygen on nickel oxide was investigated over the temperature range 275 to 385°C It was shown that the oxygen on the surface of the NiO was not equivalent with respect to isotopic exchange. Heteroexchange proceeded according to a mechanism which included the replacement of two atoms of oxygen on the oxide surface. Homomolecular exchange proceeded partially according to the heteroexchange mechanism, and partially involving exchange in an adsorbed layer without participation of the oxygen of the catalyst. Conditioning of a sample in a vacuum lead to an increased rate of isotopic exchange with concomitant lowering of the activation energy. (tr-auth)

**22212** SOLVENT ISOTOPE EFFECTS ON THE IONIZATION OF HYDROFLUORIC ACID. Kresge, A. J.; Chiang, Y. (Illinois Inst. of Tech., Chicago). J. Phys. Chem.; 77: No. 6, 822-825 (15 Mar 1973).

Measurements of fluoride ion activities using a selective-ion electrode and hydrogen ion activities using a quinhydrone electrode were performed on dilute hydrofluoric acid and hydrogen fluoride–sodium fluoride buffer solutions in $H_2O$ and $D_2O$. These determinations lead to $pK(H_2O) = 3.165 \pm 0.007$, $K(H_2O)/K(D_2O) = 2.05 \pm 0.04$ for $HF = H^+ + F^-$, and $pK(H_2O) = -0.598 \pm 0.010$, $K(H_2O)/K(D_2O) = 1.13 \pm 0.03$ for $HF + F^- = HF_2^-$. Calculations show that the dominant contribution to each isotope effect comes from the two-fold change in the moments of inertia of hydrogen fluoride produced by isotopic substitution; zero-point energy effects are small, principally because hydrogen fluoride, being a diatomic molecule, has no bending vibrations. (auth)

**22213** EFFECT OF DISPERSION ON METHANE–DEUTERIUM EXCHANGE OVER SUPPORTED NICKEL. Cece, J. M. Kingston, RI; Univ. of Rhode Island (1972). 72p. University Microfilms Order No. 73-2373.

Thesis (Ph. D.).

The exchange reactions, methane–deuterium and hydrogen–deuterium, were studied over a series of nickel-silica catalysts. Both reactions were found to proceed as a function of the metal dispersion in the catalyst. Meaningful methane–deuterium exchange reaction rates were observed between 225 and 250°C on impregnated nickel–silica catalysts which contained from 2% to 50% nickel by weight. The apparent activation energies of the stepwise (substitution of one deuterium in methane) and of the multiple (substitution of more than one deuterium in methane) exchange reactions were shown to be a function of average nickel crystallite size. It was found that silica hydroxyl groups exchanged with gaseous deuterium at 540°C. When the silica was impregnated with nickel the exchange reaction proceeded at temperatures as low as 280°C. (Diss. Abstr. Int., B)

**22214** TRITIUM ISOTOPE EFFECTS IN THE MEASUREMENT OF THE GLYCEROL PHOSPHATE AND DIHYDROXYACETONE PHOSPHATE PATHWAYS OF GLYCEROLIPID BIOSYNTHESIS IN RAT LIVER. Manning, R.; Brindley, D. N. (Univ. of Nottingham, Eng.). Biochem. J.; 130: No. 4, 1003-1012(Dec 1972).

Rat liver slices were employed to study the relative rates of incorporation of a mixture of [2-$^3$H]- or [1,3-$^3$H]-glycerol and [1-$^{14}$C] glycerol into lipids. Respiring rat liver mitochondria were found to oxidize a mixture of sn-[2-$^3$H]- and sn-[1-$^{14}$C]-glycerol 3-phosphate with a resultant increase in the $^3H/^{14}C$ ratio of the remaining sn-glycerol 3-phosphate. This increase in due to a $^3$H isotope effect of the mitochondrial sn-glycerol 3-phosphate dehydrogenase (EC 1.1.99.5), which discriminates against sn-[2-$^3$H]glycerol 3-phosphate during oxidation. (DHM)

**22215** ISOTOPE EFFECTS IN THE SECOND VIRIAL COEFFICIENTS OF DEUTERATED ETHYLENE. Goepel, W.; Dorfmueller, T. (Technische Univ., Hanover). Z. Phys. Chem. (Frankfurt); 82: No. 1-4, 58-65(Nov 1972). (In German).

The second virial coefficients of normal ethylene $C_2H_4$ and the deuterated species $C_2D_4$, $C_2H_2D_{2\,trans}$ and $C_2H_2D_{2\,gem}$ were measured in the range between 200 and 300°K. The measurements were performed with an expansion method where the gas was expanded from one vessel at 300 Torr into a second evacuated vessel. The pressures before and after the expansion which were measured with an accuracy of $10^{-3}$ Torr were used to calculate the second virial coefficients. The temperature stability of the system was $10^{-3}$ K. It was found that the virial coefficients are in the sequence $|B|_{C_2D_4} > |B|_{C_2H_2D_{2trans}} > |B|_{C_2H_2D_{2gem}} > |B|_{C_2H_4}$. The isotope effects are maximum at approximately 224°K. The maximum value of the isotope effect is 3 cm$^3$/mole between $C_2D_4$ and $C_2H_4$, and 2 cm$^3$/mole between $C_2H_2D_{2\,trans}$ and $C_2H_4$. Between the isotopic isomers $C_2H_2D_{2\,trans}$ and $C_2H_2D_{2\,gem}$ an isotope effect of 0.4 cm$^3$/mole could be observed. (auth)

**22216** INTERMOLECULAR INTERACTIONS OF DEUTERATED ETHYLENE MOLECULES IN THE GAS PHASE. Dorfmueller, T.; Goepel, W. (Technische Univ., Hanover). Z. Phys. Chem. (Frankfurt); 82: No. 1-4, 66-82(Nov 1972). (In German).

The intermolecular force parameters for the non spherical Kihara mode were calculated from virial coefficient data of the isotopic ethylenes $C_2D_4$, $C_2H_2D_{2\,trans}$, $C_2H_2D_{2\,gem}$, and $C_2H_4$. The molecular excentricities calculated from these molecular interaction data are significantly smaller then either spectroscopic or polarisability-excentricities owing to the molecular rotation during the interaction. The relaxation of translation and rotation energy into internal degrees of freedom results in the formation of "polarisation molecules". The importance of this effect can be estimated through the isotope effects in the excess molar heat of the real gas. It is shown that the study of the thermodynamic isotope effects in the gas phase, if compared to the behavior of individual molecules, as given by spectroscopic and polarisability measurements can give us an insight into the complex dynamical aspect of molecular interactions. (auth)

**22217''** ISOTOPIC EFFECT IN ANTIMONY TRIHALIDES. Kozulin, A. T.; Chebykin, N. A. (Perm State Univ., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 8, 142-143(1972). (In Russian).

A search was made for an isotope effect in the intramolecular vibrations of $SbCl_3$ and $SbBr_3$ which contained alternatively $^{121}$Sb, $^{123}$Sb, $^{35}$Cl, $^{37}$Cl, $^{79}$Br, and $^{81}$Br. The isotope effects that resulted by substituting Sb and Br isotopes were minor or insignificant, but the Cl isotopes caused a shift of ~8 cm$^{-1}$ in the valence deformation frequency. (KSW)

## *Isotope Exchange and Isotope Separation*

**22218** (MLM-2013) MOUND LABORATORY ACTIVITIES FOR THE DIVISION OF PHYSICAL RESEARCH: JULY–DECEMBER 1972. (Mound Lab., Miamisburg, Ohio). 14 Feb 1973. Contract AT-33-1-Gen-53. 70p. Dep. NTIS.

Research progress is reported on carbon isotope separation, stable isotope separation, thermal diffusion studies, low temperature studies, separation chemistry, and metallurgy at Mound Laboratory for July–December, 1972. (DHM)

**22219** SEPARATION OF NUCLEAR ISOMERS OF TELLURIUM. Fernandez Valverde, S. M. Saltillo, Mexico; Univ. de Coahuila (1972). 46p. (In Spanish).
Thesis.

From results obtained previously it was concluded that, effectively, it is possible to separate nuclear isotopes of tellurium in the ground state from the respective metastable isotopes by electrophoresis. The separation is accomplished because the chemical species present in the telluric acid after the isomeric transition $^{127m}$Te and $^{129m}$Te behave in a different manner than on being subjected to a process of paper electrophoresis. It was found that nuclear isomers in the ground state are not displaced on paper. This is probably due to the fact that the chemical change produced by the isomeric transition in hydrochloric acid solution of telluric acid forms a nonionic complex. On the other hand, the metastable isomers are encountered in the form of telluric acid, which is the original compound and undergo a displacement remaining in this form separated from the isomers in the ground state. (tr-auth)

**22220** METHOD FOR THE PREPARATION OF CARBOXYLIC ACIDS SPECIFICALLY LABELED WITH HYDROGEN ISOTOPES. Simon, H. (to Roth (Carl) oHG). German Patent 2,062,583. 22 Jun 1972. 8p. (In German).

A method is described for the specific deuterium- or tritium-labeling of carboxylic acids which may also be substituted by halogen atoms and/or hydroxyl or alkoxy groups, respectively. The acid to be labeled is incubated with Clostridium cluyvery (or one of its mutants) anaerobically in a deuterated or tritiated medium. The microorganisms affect the exchange reaction catalytically. (GF)

**22221** ISOTOPE FRACTIONATION DURING GAS-CHROMATOGRAPHIC SEPARATIONS: COMMENT. Van Hook, W. A. (Boris Kidric Inst. of Nuclear Science, Belgrade). J. Chromatogr. Sci.; 10: No. 3, 191-192(1972).

Values obtained by Gunter and Gleason (Analyt. Abstr., 1972, 22, 93) on $^{12}$C–$^{13}$C, $^{16}$O–$^{18}$O and H–D isotope fractionation by chromatography of $CO_2$ and methane on silica gel are re-interpreted in terms of the theory of isotope effects in condensed phase systems. (Anal. Abstr.)

**22222** PROCEDURE FOR THE SEPARATION OF THE ISOTOPE $^{235}$U FROM $^{238}$U. James, D. B. (to Atlantic Richfield Co.). German Patent 2,155,895. 25 May 1972. 17p. (In German).

An isotope separation procedure based on cation-exchange method is described. Uranium(VI) ions are converted to U(IV) on a column loaded with reducing ions, Ti(III), and then eluted with an oxidizing agent ($FeCl_3$). The U(VI) leaving the column is enriched $^{235}$U compared to the charge solution. A strongly acid cation exchange resin based on a sulfonized copolymer of styrene and divinylbenzene is used. (GF)

**22223** STUDIES OF RUTHENIUM COMPLEXES. III. Kinetics of isotopic ligand-exchange reactions of halogenopentaammineruthenium(III) complexes in aqueous solution. Shinohara, T.; Yamada, T.; Takebayashi, N.; Hiraki, S. I.; Ohyoshi, A. (Kumamoto Univ., Japan). Bull. Chem. Soc. Jap.; 45: No. 10, 3081-3083(Oct 1972).

Kinetic studies of isotopic ligand exchange reactions, $[Ru(NH_3)_5X]^{2+} + X^{*-} = [Ru(NH_3)_5X^*]^{2+} + X^-$, where X = Cl, Br, and I, were made in aqueous solutions. The effects of the hydrogen- and halide-ion concentrations, and of the ionic strength of the aqueous solution on the exchange rate were not observed under certain definite experimental conditions. The rate constants were determined to be $3.15 \times 10^{-4}$ sec$^{-1}$ for the chloropentaammine $3.63 \times 10^{-4}$ sec$^{-1}$ for the bromopentaammine, and 1.1 $10^{-4}$ sec$^{-1}$ for the iodopentaammine at 80°C. The energies of activation were 20 kcal/mole (chloropentaamine), 23 kcal/mole (bromopentaamine), and 30 kcal/mole (iodopentaammine). The reactions proceed through the following two steps: $[Ru(NH_3)_5X]^{2+} + H_2O \rightarrow [Ru(NH_3)_5H_2O]^{3+} + X^-$; $[Ru(NH_3)_5H_2O]^{3+} + X^{*-} \rightarrow [Ru \times (NH_3)_5X^*]^{2+} + H_2O$. The first step is regarded as the rate-determining one. (auth)

**22224** CATALYTIC EXCHANGE OF HYDROGEN–DEUTERIUM ON COPPER-NICKEL ALLOY PLATES AFTER VARIOUS SURFACE TREATMENTS. Takasu, Y.; Yamashina, T. (Hokkaido Univ., Sapporo). Bull. Chem. Soc. Jap.; 45: No. 10, 2997-3002 (Oct 1972).

The catalytic activities of nine copper–nickel alloys (5 cm$^2$ in area) in hydrogen–deuterium exchange were examined at 1.5 Torr partial pressures of hydrogen and deuterium, using an ultra-high vacuum apparatus incorporated with an omegatron mass spectrometer for continuous gas analysis. Without any surface treatment, the activity was greatest on pure nickel, decreased gradually as the content of copper in the alloys increased and virtually vanished in the alloys containing copper more than 70%. The activity of each alloy sample was observed to be enhanced considerably by a slight surface treatment of oxidation–reduction ($P_{O_2}$ = 2.3 Torr at 500°C for 1 min, $P_{H_2}$ = 16 Torr at 300°C for 2 hr). The activity of the 85% copper alloy after the oxidation–reduction treatment was greatest, one hundred times that of pure nickel. Annealing for a short time in an ultra-high vacuum subsequent to the oxidation–reduction treatment caused the catalytic activity to decrease abruptly at a critical temperature (425°C). On the bases of the electron microscopic observations and the measurement of the surface roughness changed by the pre-treatments, the nature of active sites on copper–nickel alloys was discussed. (auth)

**22225** TERNARY DIFFUSION IN THE $^{20}$Ne–$^{22}$Ne–$CO_2$ SYSTEM. Oishi, Y.; Sugisaki, M.; Kamei, Y.; Shono, Y. (Kyushu Univ., Fukuoka). Bull. Chem. Soc. Jap.; 45: No. 10, 2984-2988 (Oct 1972).

Self-diffusion coefficients of $CO_2$ of the binary system of Ne and $CO_2$ were measured for the whole composition range at 25°C under 760 mm Hg. The system was also analyzed as a ternary system of $^{20}$Ne, $^{22}$Ne, and $CO_2$. The isotope separation of $^{20}$Ne and $^{22}$Ne during the course of diffusion was measured and analyzed by means of the ternary diffusion equations obtained by an extension of Darken's binary diffusion equation. The experimentally observed $^{22}$Ne/$^{20}$Ne ratios agreed well with the values calculated by the equations. The results show that the concept of the intrinsic diffusion flux density, introduced by Darken for binary diffusion, is valid and applicable to ternary diffusion in the gaseous system. (auth)

**22226** ELECTROMIGRATORY ISOTOPE SEPARATION AND ION MOBILITY DETERMINATION IN MOLTEN SALTS. Lyubimov, V. N. (Inst. of Inorganic Chemistry, Novosibirsk, USSR). Usp. Khim.; 41: No. 3, 410-458(Mar 1972). (In Russian).

Ion electromigration techniques were applied to the separation of stable isotopes under laboratory conditions and in larger scale equipment. The basic principles and the phenomenological theory of the countercurrent migration method were examined. Choice of apparatus and mode of operating were explored in these tests. The experimental data on separation efficiency in molten salt systems were compared in tabular form with data from other methods. Ion mobility was determined by countercurrent migration which furnished information on the structure of the media through which the ions moved, and on the mechanism of the movement itself. It is suggested that isotopic separation by ion electromigration occurs by several mechanisms, the relative contribution of which to the total effect is temperature-dependent. (tr-auth)

**22227** HIGH PERFORMANCE TERNARY Ni–$Cr_2$–$O_3$–$Al_2$–$O_3$ MIXED CATALYSTS FOR HYDROGEN–STEAM DEUTERIUM EXCHANGE. Abou El-Nour; Schuetze, H. (Zentralinstitut fuer Isotopen- und Strahlenforschung, Leipzig). Isotopenpraxis; 8: No. 10, 391-396(Oct 1972). (In German).

The hypothesis that the specific activity of some binary Ni–$Cr_2O_3$ mixed catalyst used for deuterium exchange in a hydrogen-steam system may be increased by synergesis caused by the addition of a suitable third component was investigated. $Al_2O_3$ proved to be especially suitable to meet the demands to be stipulated with regard to the third component. The measured specific activities of the investigated ternary mixed catalysts show that in conformity with the hypothesis within a certain range of concentration ratios (80 to 85 mole % Ni, 5 to 15 mole per cent $Cr_2O_3$ and 5 to 15 mole % $Al_2O_3$) addition of $Al_2O_3$ to the binary Ni–$Cr_2O_3$ mixed catalyst yields a significant synergetic effect. (auth)

**22228** SEPARATION OF ALKALINE-EARTH-METAL ISOTOPES BY ION EXCHANGE. II. Study on Strontium. Aaltonen, J. (Univ. of Helsinki). Acta Chem. Fenn.; 45: No. 4, 141-144(1972).

A solution of $Sr(NO_3)_2$ (0.05% in Sr, and containing 0.5 μCi of $^{85}$Sr per ml), adjusted to pH 1 with $HNO_3$, was passed through a column (100 cm × 7 mm) of Dowex 50-X8 resin ($NH_4^+$ form; 400 mesh). The resin was washed with $H_2O$ (60 ml), then neutralized with 0.5M $NH_4NO_3$ (100 ml), and $Sr^{2+}$ ions were eluted with 4M ammonium 2-hydroxyisobutyrate (6 ml per hr). The eluate was recycled seven times, then fractions were collected at intervals of 30 min. The $^{85}$Sr activity of the fractions was measured with a scintillation detector (NaI crystal and a single-channel analyzer). The relative abundance of $^{84}$Sr, $^{86}$Sr, $^{87}$Sr, and $^{88}$Sr in the fractions was determined by mass spectroscopy. The separation factor for the isotopes $^{84}$Sr and $^{88}$Sr, calculated from the isotopic composition of the eluted fractions, was 1.000097 ± 0.000007. (Anal. Abstr.)

**22229** ANALYSIS OF REACTION STRUCTURE OF HYDROGEN ELECTRODE REACTION WITH DEUTERIUM TRACER AND DETERMINATION OF STOICHIOMETRIC NUMBER. Matsushima, T.; Enyo, M. (Hokkaido Univ., Sapporo). Shokubai; 13: No. 4, 177-180(Aug 1971). (In Japanese).

Studies were made on the change in the course of time in isotopic composition of hydrogen gas containing deuterium. From results of these studies, it was found that the path of hydrogen electrode reaction is independent of the nature of the metal used as the electrode such as Rh, Ni, Ir, Ag, Pt, and Au, and the composition of solution. The path of reaction consists of dissociation adsorption of hydrogen molecules and ionization of hydrogen atoms. When hydrogen pressure is low, the former is rate-determining. With increase of the pressure of hydrogen, the latter reaction becomes rate-determining. During transition of the rate-determining elementary reaction, the stoichiometric number determined by conventional method does not correspond to that of the specific elementary reaction, but is a function of the ratio of the rates of both elementary reactions in equilibrium system. This function was experimentally examined. Quantitative study was also made on the effect of the isotopic reaction. It was thus confirmed that results of analysis on reaction structure obtained with deuterium can be proved by the use of stoichiometric numbers. (auth)

### *Feed Materials Processing*

*Refer also to abstract 22475.*

**22230** (EURFNR-1043) PILOT-SCALE PRODUCTION OF $UF_6$ BY THE DIRECT FLUORINATION OF $UO_2$ POWDER. Harnie, R.; Goossens, W.; Ooms, E. (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)). Jun 1972. 88p. Dep. NTIS $6.50.

Work performed under United States-Euratom Fast Reactor Exchange Program.

The experimental research in the pilot installation EBO, built under the reprocessing project, was oriented to the preparation of $UF_6$ from pulverized $UO_2$. This preparation was performed by treating the fluidized powder by $ClF_3$ or $F_2$. In the first runs, the conversion of a definite reactor load was determined. Afterwards, the installation was adapted in order to be able to perform a continuous exploitation. The chemical data and the technological experience gained during these runs are discussed. (auth)

**22231** METHOD FOR THE ELIMINATION OF ELEMENTS DISTURBING THE CHEMICAL ORE DRESSING BY MEANS OF MAGNETITE AND BARIUM SULFATE AS LOADING MATERIAL AND ITS RECOVERY. Wilhelms, K. E. (to Uranerzbergbau GmbH und Co. KG). German Patent 2,039,563. 10 Feb 1972. 3p. (In German).

A procedure is described that allows removal of those elements interfering with the chemical dressing of uranium ores. Magnetite and barium sulfate or other loading agents are used to extract and enrich uranium ores or other minerals on an economic basis. (GF)

**22232** CALCULATION OF THE DIMENSIONS OF A BALL MILL TO TREAT URANIUM MINERALS. Estrada Correa, E. Mexico City; Univ. Nacional Autonoma de Mexico (1972). 112p. (In Spanish).

Thesis.

A new theory has been tested establishing that the total work required to crush and grind varies with the fourth root of the size of the product. When at the beginning of the work the size of the feed and the size of the product are known, the theory permits the rapid calculation of the work required for any amount of reduction and permits direct comparisons of efficiency. The relative efficiencies of operations and different circuits, involving feed and different sizes of product can be compared directly and since tests have been made in the laboratory, the relative efficiencies of plants that reduce various materials can be compared. (tr-auth)

**22233** PRELIMINARY PLAN FOR A 300 TON/YEAR PLANT FOR THE PURIFICATION OF SODIUM URANATE. Arroyo Berdon, E.; Castro Bonifant, V. M.; Fortoul Curiel, J. O. Mexico City; Universidad Nacional Autonoma de Mexico (1972). 189p. (In Spanish).

Thesis.

This is a preliminary project for a pilot plant for refining uranium concentrates with a capacity to produce 300 tons/year of $U_3O_8$ in the product. Uranium trioxide of nuclear grade will be obtained which constitutes a great advance in the process of production of nuclear fuels, which will decrease the flight of capital abroad to buy nuclear fuel that Mexican power reactors will use. Pulsed columns will be used to purify the uranium concentrates. The plant will operate continuously day and night (3 shifts of 8 hours). The investment necessary for the construction and installation of this plant is $4,832,599.00. The cost of conversion of sodium uranate to uranium trioxide of nuclear purity is $13.47/kg $U_3O_8$. (tr-auth)

## Radiation Chemistry

*Refer also to abstracts 22263, 22303, and 22653.*

**22234** (COO-3035-1) RADIATION CROSSLINKING OF POLYMERS WITH SEGREGATED METALLIC PARTICLES. Annual Report, June 1, 1970–May 31, 1971. Turner, D. T.; Malliaris, A.; Kusy, R. P. (Drexel Univ., Philadelphia, PA. Dept. of Metallurgical Engineering). 8 Jan 1973. Contract AT(11-1)-3035. 82p. Dep. NTIS.

Research is reported on electrical conductivity of a polyurethane elastomer containing segregated particles of nickel; radiation processing of a conductive polyurethane elastomer containing segregated particles of nickel; and corrosion resistance of polyethylene and polytetrafluoroethylene conductive composites. (DHM)

**22235** (JAERI-M-4878) BEHAVIOR OF THE FISSION PRODUCTS RELEASED INTO CHEMICAL REACTANTS FROM U–Pd ALLOY FOIL. Moriyama, N.; Lee, H.-Y.; Sato, S.; Ikezoe, Y.; Shimizu, S. (Japan Atomic Energy Research Inst., Tokyo). Jul 1972. 9p. (In Japanese).

Ethylene gas was sealed in a stainless steel capsule, in the presence of uranium–palladium alloy foil coated with platinum, and irradiated in a nuclear reactor. Fission fragments produced lose their kinetic energy first within the nuclear fuel, then in the ethylene gas and finally on the wall of the capsule. Only a trace amount of the fission products was detected in the ethylene gas, though the kinetic energy of the fission fragments escaping from the fuel was almost all consumed in the gas. The amount of fission products within the fuel was nearly the same as that calculated and that on the wall of the capsule was nearly equivalent to the amount presumably stopped in the gas. The sum of $\gamma$ activities of all the fission products detected was approximately equal to that calculated from the empirical formula proposed by K. Way and E. P. Wigner, showing the reliability of the observed values. It was indicated that the decontamination problem of a fissiochemical reaction system would be insignificant, when gaseous reactants would form gaseous products in the presence of a solid nuclear fuel. (auth)

**22236** (KFK-1717) PROPERTIES AND RADIOCHEMICAL REACTIONS OF INTERMEDIATE PRODUCTS IN AMORPHOUS AND CRYSTALLINE ALKALI HYDROXIDE HYDRATES. Wieczorek, H. (Kernforschungszentrum, Karlsruhe (West Germany). Institut Fuer Radiochemie). Dec 1972. 85p. (In German). Dep. NTIS (U. S. Sales Only) $6.25.

The reaction of irradiation produced electrons in crystalline and amorphous alkali hydroxide hydrates is discussed. Ionizing radiation produces diamagnetic centers, nonabsorbing in the visible region, in crystalline alkali hydroxide hydrates at low temperature, which decompose thermally to electrons. These electrons are stabilized in a crystalline matrix. The content of crystalline water modifies the portion of the stabilized electrons and their energy level. The photochemical and thermal properties of these electrons are similar to those in alkaline glasses. Reactions of mobile as well as photo- or thermochemically delocalized electrons with aromatic carboxylic acids in amorphous alkali hydroxide hydrates yield stabilized anion radicals, which are identified by their optical and ESR spectra. Protonation of the anion radicals, known to occur rapidly in liquid polar systems, seemingly is not a significant process in the frozen solutions. A photochemically induced and reversible electron transfer between the anion radical and the trapping sites of the electrons is observed. (auth)

**22237** (SGAE–2062) OPEN RING PRODUCTS OF THE RADIOLYSIS OF THE PERFLUOROMETHYLCYCLOHEXANES. Wiesboeck, R. (Oesterreichische Studiengesellschaft fuer Atomenergie G.M.B.H., Seibersdorf. Institut fuer Chemie). Nov 1972. 6p. (In German). Dep. NTIS (U. S. Sales Only).

Samples of perfluoromethylcyclohexane were irradiated with 200 Mrad. The radiolysis products were separated by gas-chromatography and measured by mass spectrometry. The yield was 78.3% for $C_{14}F_{26}$ and 21.7% for $C_{14}F_{28}$; the G-values were 0.41 and 0.11, respectively. The open ring product $C_7F_{16}$ was also observed and showed a G-value of 0.12. (HBG)

**22238** INVESTIGATION OF PALM OIL AFTER GAMMA IRRADIATION. Qualitative and Quantitative Analysis of Carotene and Carotenoids and Their Radiolysis Products by Thin Layer Chromatography. Bancher, E.; Washuettl, J.; Riederer, P. (Technische Hochschule, Vienna). Seifen-Oele-Fette-Wachse; 97: No. 5, 121-126(1971). (In German).

Various adsorbents and developing solvents were used for this investigation, the results of which showed that retinol and retinal were formed in palm oil exposed to $\gamma$ radiation. The carotene and carotenoid contents, however, decreased with increasing dosage at a rate higher than that of the increase in retinol. (Anal. Abstr.)

**22239** ROLE OF WATER RADIOLYSIS PRODUCTS IN THE DECOMPOSITION OF GLUCOSAMINE IN FROZEN AQUEOUS SOLUTIONS. Sharpatyi, V. A.; Nadzhafova, M. A. (Inst. of Chemical Physics, Moscow). Izv. Akad. Nauk SSSR, Ser. Khim.; No. 11 2564-2569(Nov 1972). (In Russian).

EPR spectra of glucosamine solutions in $H_2O$ which had been irradiated at 77°C with a $^{60}$Co source were used to determine the effects of radiolysis products of the $H_2O$ on the decomposition of the organic substance. In addition, optical absorption spectra of the frozen irradiated solutions (glucosamine + 10 M KOH and glucosamine + 5M $NaH_2PO_4$) were determined with a spectrophotometer. The data indicated that $H_2O^+$ (OH) and an electron participate in the decomposition of glucosamine at 77°K. (KSW).

**22240** INVESTIGATION OF THE PHYSICOCHEMICAL PROPERTIES OF GRAFTS OF COPOLYMERS OF POLY(VINYL ALCOHOL) WITH POLY(VINYL PYRIDINE). Tashmukhamedov, S. A.; Larin, P. P.; Karabaev, A. Sh.; (and others) Tashkent State Univ.). Acta Chim. Acad. Sci. Hung.; 74: No. 4, 453-460(1972). (In Russian).

It was shown that in the presence of water or methanol in the reaction mixture the ratio of components in the copolymer changes. The possibility of quantitative determination of poly(vinylpyridine) in its copolymer with poly(vinyl alcohol) by means of ir spectroscopy was demonstrated. Studies on the solubility, swelling and the density of PVA–PVP graft copolymers have revealed that in the course of radiation chemical copolymerization the macromolecules undergo structuralization to a degree increasing with increasing irradiation dose. It was shown that, in addition to the chemical composition and irradiation dose, the density of graft copolymers depends also on the nature of solvent used in the synthesis. (auth)

**22241** SEMICONTINUUM MODEL FOR TRAPPED ELECTRONS IN POLAR LIQUIDS AND SOLIDS. Trends With Matrix Polarity. Fueki, K.; Feng, D. F.; Kevan, L. (Wayne State Univ., Detroit). AT(11-1)-2086. J. Amer. Chem. Soc.; 95: No. 5, 1398-1047(7 Mar 1973).

A semicontinuum model is extended to trapped electrons in 2-methyltetrahydrofuran glass and in three amine glasses at 77°K. It is shown to account for recent experimental results quite well. The semicontinuum model was also modified for trapped electrons in aqueous glasses like 10 M NaOH by neglecting long-range polarization interactions. This modification successfully predicts no bound excited state in agreement with experiment. Revised calculations are given for electrons in water and ice and configuration coordinate diagrams are presented for the above matrices and for electrons in liquid and glassy methanol and ethanol. The effects of the various physical constants of the matrices on the trapped electron energy level structure are discussed from the viewpoint of matrix polarity. (auth)

**22242** STUDIES OF HYDROGEN ATOM ABSTRACTION BY METHYL RADICALS AT LOW TEMPERATURES IN GAMMA-IRRADIATED CRYSTALLINE ORGANIC COMPOUNDS. Wang, J. T. Knoxville, TN; Univ. of Tennessee (1972). 119p. University Microfilms Order No. 73-2507.

Thesis (Ph. D.).

Methyl radicals ($CH_3$· and $CD_3$·) are formed in γ irradiated crystalline methyl isocyanide ($CH_3NC$ and $CD_3NC$) at 77°K. ESR studies show that the $CH_3$· radicals decay by hydrogen atom abstraction in $CH_3NC$ as evidenced by the simultaneous growth of the ·$CH_2NC$ radical. Detailed kinetic studies of this reaction were carried out at several temperatures between 77 and 120°K. The Arrhenius plot (the logarithm of the rate constants against 1/T) is nonlinear and the apparent activation energies increase from 1.4 kcal $mol^{-1}$ at 77°K to 4.5 kcal $mol^{-1}$ at 120°K. A large deuterium/hydrogen kinetic isotope effect was evaluated by comparing the slow decay of $CH_3$· radicals in 90 mol % $CD_3NC$ with the decay of $CH_3$· radicals in pure $CH_3NC$. The value of this isotope effect (>1 × $10^3$ at 110°K) is at least a factor of five greater than the maximum possible effect calculated from the difference in zero-point energies of the appropriate stretching vibrations. Both the nonlinearity of the Arrhenius plot and the large kinetic isotope effect for hydrogen abstraction reaction can be explained by quantum mechanical tunneling. Dimer and monomer radical anions are formed in Crystal I and Crystal II, respectively, of acetonitrile by γ irradiation at 77°K. These radical anions are photobleached by visible light to give $CH_3$· radicals and $CN^-$ anions. These $CH_3$· radicals then undergo abstraction and recovery reactions at higher temperatures in the dark. ESR studies show that when γ irradiated Crystal I and Crystal II of $CH_3CN$ and $CD_3CN$ mixtures are photobleached at 77°K with visible light, $CH_3$· and $CD_3$· radicals are produced. The relative intensities of the $CH_3$· radicals formed for different compositions of the mixture give clear evidence for an isotope effect on electron capture. The isotope effect is almost the same at 77 and 4°K. The quartet signal intensity of the $CH_3$· radical is almost the same in 25 mole percent of $CH_3CN$ in $CD_3CN$ as in the pure $CH_3CN$. In mixtures with less $CH_3CN$, the proportion of the $CH_3$· radicals formed after photobleaching is much larger than the $CH_3CN$ percentage in the mixtures. Since approximately the same number of radicals are formed at 4 and 77°K, this suggests the possibility of fast electron rather than thermal electron capture. When methyl isocyanide-$h_3$ or -$d_3$ is incorporated into the Crystal I of acetonitrile, the formation of the dimer radical anion during γ irradiation at 77°K is reduced or eliminated. (DHM)

**22243** PROCESS FOR TREATING POLYMERIC SUBSTRATES WITH HIGH-ENERGY RADIATION. Hook, E. O.; Nichols, L. D. (to Moleculon Research Corp.). U. S. Patent 3,711,389. 16 Jan 1973. Filed date 15 Jul 1969. 16p.

This invention pertains to the use of ionizing radiation together with additives based on unsaturated derivatives of phosphazenes (1,3,5,7,2,4,6,8-tetrazatetraphosphocine and 1,3,5,2,4,6-triazatriphosphorine) to impart improved flame resistance, heat resistance, solvent resistance, or deformation resistance to a variety of materials. The stability of the phosphazene nucleus and its compatibility with a wide variety of materials give additives based on the phosphazenes compatibility and usefulness in a large variety of substrates. Furthermore, the high phosphorus and nitrogen content of phosphazenes confers reduced flammability on materials in which they are incorporated. Exposure of the substrate to ionizing radiation leads to radioinduced grafting of the polymerizable olefinic groups, thereby bonding the phosphazene additive to the substrate material, and imparting increased heat resistance, solvent resistance, and deformation resistance to the modified product. (JGB)

**22244** ESR AND OPTICAL STUDIES OF ALIPHATIC RADICAL ANIONS AND RADICAL-ANION PAIRS IN γ-IRRADIATED CRYSTALLINE SOLIDS AT LOW TEMPERATURES. Chung, Y. J. Knoxville, TN; Univ. of Tennessee (1972). 129p. University Microfilms Order No. 73-2435.

Thesis (Ph. D.).

ESR studies of intermediate species formed by nondissociative and dissociative electron capture processes during γ-irradiation of crystalline organic compounds at low temperatures are considered. Aliphatic molecules with low-lying vacant orbitals including alkyl (tert-butyl, ethyl and methyl) isocyanates, alkyl isothiocyanates, acrylonitrile, acetone, and N,N-dimethylformamide were found to form stable radical anions at 77°K in the dark. The identification of the tert-butyl isocyanate radical anion is particularly definitive since it is based on the ESR hyperfine structure as well as on photobleaching and electron scavenging studies. This radical anion is characterized by a well-resolved 1 : 1 : 1 triplet (g = 2.0018) with hfs of 4.8 G and an optical absorption band ($\lambda_{max}$ at 330 nm); on photobleaching it dissociates to produce the tert-butyl radical. The observation of radical-anion pairs derived from tert-butyl iodide, tert-butyl isothiocyanate, and dimethyl sulfoxide-$d_6$ is also reported. The tert-butyl radical-iodide anion pair was formed in γ-irradiated crystalline tert-butyl isocyanate doped with tert-butyl iodide at 77°K. From the examination of angular-dependent ESR spectra for this radical-anion pair, the hfs of protons from the tert-butyl group is found to be in the range of 21 to 22 G and the corresponding hfs of iodine is in the range of 5 to 6.5 G. On suddenly annealing the γ-irradiated sample in situ at ca. 150°K for a few minutes, the tert-butyl radical-iodide anion pair dissociates irreversibly into the free tert-butyl radical and the iodide anion. In the case of the tert-butyl radical-thiocyanate anion pair, the radical–anion interaction is manifested by a broadening (line width 5 G) of the tert-butyl radical ESR spectrum in the dark at 77°K. (DHM)

**22245** VACUUM LINE FOR LIQUID AMMONIA RADIOLYSIS INVESTIGATIONS. Blum, A.; Broszkiewicz, R. K. (Inst. of Nuclear Research, Warsaw). Nukleonika; 17: No. 11, 599-606(1972).

The vacuum line for liquid ammonia radiolysis investigation is described. The operations of ammonia and additives purification, measuring, sampling and direct GC analysis of irradiated cell gas content are discussed. Original devices (GC analytical head and preparative homogenizer) are shown and described. (auth)

**22246** EFFECT OF RADIOLYTIC DEGRADATION OF DILUENT-TBP NITRIC ACID SYSTEMS ON THE EXTRACTION OF URANYL NITRATE. Nowak, Z.; Krejzler, R. (Inst. of Nuclear Research, Swierk, Poland). Nukleonika; 17: No. 10, 521-527 (1972). (In Polish).

Extraction of uranyl nitrate was examined in the irradiated TBP–diluent–$HNO_3$ systems. The relationship between the extraction and the dose as well as the concentration of nitric acid in the irradiated solvent were determined. Also the influence of diluent on the extraction was investigated. It was found that percent E of uranyl nitrate decrease with growing nitric acid concentration and the dose. In the systems under investigation the highest extraction was found for solutions of TBP in aromatic hydrocarbons or cycloparaffins mixtures. (auth)

**22247** LOW-TEMPERATURE ALKYLATION OF BENZENE WITH PROPENE IN THE PRESENCE OF γ-IRRADIATED ALUMINUM SILICATE OR UNDER THE ACTION OF UV LIGHT. Kolesnikov, I. M.; Panchenkov, G. M.; Mamedova, S. L.; Kislenko, N. N.; Tarkhova, L. G. (Inst. of Oil and Gas Industry, Moscow). Kinet. Katal.; 13: No. 6, 1592-1593(1972). (In Russian).

An industrial aluminum silicate ($SiO_2$–11% $Al_2O_3$–0.33% Na–0.11% $Fe_2O_3$, specific weight 2.52 c/cm$^3$, specific surface 311 m$^2$/g, 55% porosity) was heated to 580°C in dry air for 6 hr then irradiated with γ-rays (source not specified) for a dose of 1 MR. Using this treated catalyst, the alkylation of benzene with propene was studied at 65°C and atmospheric pressure. Some experiments were conducted while fresh catalyst was being exposed to uv light. The action of γ-rays or uv light increased the activity of the catalyst so as to multiply the conversion of benzene to its alkalated products by a factor of 2 or 3. (KSW)

**22248** LOCALIZATION OF FREE VALENCY IN IRRADIATED PEPTIDES CONTAINING HISTIDINE. Panin, V. I.; Ponomareva-Stepnaya, M. A.; Molodov, L. A.; Usatyi, A. F. Biofizika; 17: No. 4, 594-598(Jul 1972). (In Russian).

The localization of free valency in irradiated (one MeV electrons) histidine–glycine peptides was studied by EPR over the temperature range 150 to 300°K. The probability of forming radicals in a histidine unit was determined as a function of location in the peptide chain. Deamination, decarboxylation, and splitting of the peptide linkage were observed in tetrapeptides. By increasing the temperature of samples which had been irradiated at 150°K, secondary reactions of "terminal" radicals (–RCH) were formed with intact units of the neighboring peptide molecules. Terminal radicals that were stable at room temperature were formed by splitting an atom of hydrogen from amino acid groups of the peptide. The EPR spectra were accordingly modified. (tr-auth)

**22249** PROCEDURE FOR TREATMENT OF AQUEOUS SOLUTIONS CONTAINING FERROUS COMPOUNDS FOR THEIR REMOVAL FROM THE SOLUTION. Steinberg, M.; Pruzansky, J. (to United States Atomic Energy Commission). Norwegian Patent 124,923. 29 Oct 1968. Priority date 3 Nov 1967, United States of America (USA). 7p. (In Norwegian).

A very dilute solution containing ferrous ions in the ppM range with a pH value less than 6.0 is aerated while subject to ionizing irradiation of at least 1000 rad/h until virtually all ferrous compounds are oxidized to ferric compounds. The solution is thereafter brought in contact with calcium carbonate in situ and $Fe_2O_3$ precipitated out. The calcium carbonate may be dispersed in the solution during irradiation. The process is carried out at normal pressure and temperature. (INIS)

**22250** RADIOCHEMICAL GRAFT POLYMERIZATION OF POLYETHYLENE WITH STYRENE: CALIBRATION OF THE ATTENUATED TOTAL REFLECTANCE SPECTROSCOPIC DATA FOR DETERMINATION OF THE DEGREE OF GRAFTING. Roloff, H.; Schwind, A. E.; Zilinski, E.; Wagner, H. (Inst. fuer Hochenergiephysik, Zeuchen, Ger.). Plaste Kaut.; 19: No. 1, 14-16(1972). (In German).

The degree of surface grafting of styrene on to polyethylene foil is determined by attenuated total reflectance spectrometry from the ratio of the extinction of the 700-cm$^{-1}$ CH band of the polystyrene and the mean of the extinctions of the 720-cm$^{-1}$ and 730-cm$^{-1}$ $CH_2$ bands of the polyethylene. A calibration graph was constructed by reference to the gravimetrically determined degrees of grafting. (Anal. Abstr.)

**22251** YIELDS OF FRAGMENT IONS IN THE RADIOLYSIS OF LIQUID N-BUTANE. Fujisaki, N.; Wada, T.; Shida, S.; Hatano, Y. (Tokyo Inst. of Tech.). J. Phys. Chem.; 77: No. 6, 755-758(15 Mar 1973).

An attempt to estimate the yields of fragment ions was made in the γ radiolysis of liquid n-butane. The G values of $C_2H_5^+$, $C_3H_7^+$, and $C_4H_9^+$ are estimated by using charge scavengers such as sulfur hexafluoride and ammonia to be at least about 0.25, 0.15, and 0.6, respectively. Their yields are also estimated by measuring the isotopic composition of ethane and propane formed in the radiolysis of equimolar mixtures of n-$C_4H_{10}$–n-$C_4D_{10}$. Although somewhat large errors are involved in the isotopic composition, the yields of fragment ions in both the estimations seem to be in fairly good agreement with each other, except for the yield of butyl ion, which could not be estimated by the latter method. (auth)

**22252** REACTIONS OF FLUORINATED BENZENES WITH HYDRATED ELECTRONS AND HYDROXYL RADICALS IN AQUEOUS SOLUTIONS. Koster, R.; Asmus, K. D. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). J. Phys. Chem.; 77: No. 6, 749-755(15 Mar 1973).

The reactions of fluorinated benzenes with hydrated electrons and hydroxyl radicals in aqueous solutions were investigated by pulse radiolysis and γ-irradiation experiments. One fluoride ion per attacking $e_{aq}^-$ is eliminated from the higher fluorinated compounds via a dissociative electron capture process. The yields of $F^-$ ions are lower in the reaction of $e_{aq}^-$ with mono-, o-di-, and p-difluorobenzene. The majority of electrons here interact with the aromatic ring, and the molecular anions thus formed are neutralized to yield fluorocyclohexadienyl radicals. The oxidation of fluorinated benzenes by hydroxyl radicals occurs via addition of the OH· to any of the six carbon atoms with almost equal probability. If the attacked carbon atom carries a hydrogen atom, a fluorohydroxycyclohexadienyl radical is produced. The addition to a carbon atom carrying a fluorine atom leads to the elimination of hydrogen fluoride. Rate constants were determined for the reactions of the fluorinated benzenes with $e_{aq}^-$ and OH· and for the reactions of transient species produced from these processes. Radicals and stable products were also characterized by their optical absorption spectra. Mechanistic details of the reduction and oxidation reactions are discussed. (auth)

**22253** FORMATION OF PRIMARY YIELDS OF HYDROXYL RADICAL AND HYDRATED ELECTRON IN THE γ-RADIOLYSIS OF WATER. Draganic, Z. D.; Draganic, I. G. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). J. Phys. Chem.; 77: No. 6 765-772 (15 Mar 1973).

The formation of $G_{OH}$ and $G_{e_{aq}^-}$ was studied in γ-irradiated aqueous solutions containing selected mixtures of scavengers for both oxidizing and reducing primary radical products of water decomposition. Various assumptions based on the free-radical model of water radiolysis were experimentally tested. It was found that efficient scavenging of $e_{aq}^-$ increases not only $G_{e_{aq}^-}$ but also $G_{OH}$, by reducing the extent of water re-formation and leaving more OH radicals for other reactions. Similarly, the removal of OH leads not only to an increase in $G_{OH}$ but also in $G_{e_{aq}^-}$. Unifying curves were obtained for the dependence of observed fractional changes, $G/G^0$, on reactivities. The results obtained for solutions containing simultaneously larger amounts of scavengers for both the hydroxyl radical and hydrated electron fit the unifying curves well and point out that the secondary spur reactions are exceptions even at reactivities up to about $10^{10}$ sec$^{-1}$. It was found that the yield of water decomposition increases with reactivity. The values of $G(-H_2O)$, calculated according to the equation of material balance both from the primary oxidizing and reducing yields, agree well up to the reactivity of $10^9$ sec$^{-1}$. At larger reactivities the water decomposition yields calculated from the yields of primary reducing species are lower and possible reasons for this are considered. A summary of the reactivity influence on all primary free-radical and molecular yields of water γ-radiolysis is given. (auth)

**22254** ELECTRON PARAMAGNETIC RESONANCE EVIDENCE FOR A PEROXY TYPE SUPEROXIDE ION ON SURFACES. Ben Taarit, Y. B.; Lunsford, J. H. (Texas A and M Univ., College Station). J. Phys. Chem.; 77: No. 6, 780-783 (15 Mar 1973).

The oxygen-17 hyperfine structure for the superoxide ion formed on a decationated zeolite, which was subjected to γ irradiation, and molybdenum(VI) supported on silica gel confirms that the two oxygen atoms are unequal. Two sets of hyperfine lines were observed for each surface. These are characterized by $\alpha_{yy}(1) = 63 \pm 1$ G and $\alpha_{yy}(2) = 82 \pm 1$ G for the zeolite and $\alpha_{yy}(1) = 69 \pm 1$ G and $\alpha_{yy}(2) = 82 \pm 1$ G for the supported molybdenum. The related sextets responded in exactly the same manner with respect to the rate of formation, thermal stability, and response to variations in the microwave power. The $^{17}O^{17}O^-$ pattern was also consistent with the peroxy type structure. The surface-to-ion bond shows from 95 to 100% ionic character, which is considerably different from organic peroxy radicals. (auth)

**22255** ROLE OF WATER IN THE THERMAL AND RADIOLYTIC REDUCTION OF ALKALI-HEXACYANOFERRATES(III). Raj, D.; Danon, J. (Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro). Radiochem. Radioanal. Lett.; 13: No. 2, 83-88(5 Mar 1973).

Moessbauer spectroscopic investigations were carried out to study the thermal decompositions of the hexacyanoferrates(III) of lithium, potassium, sodium, and rubidium. The presence of water plays an important role in both radiolytic and thermal reduction processes. While in the former it yields hydrogen radicals, in the latter, it acts like a catalyst in forming an aquapentacyano complex and thus decreasing the thermal decomposition temperature. (auth)

**22256** RADIATION PROTECTION OF POLY(METHYL METHACRYLATE) BY GLASS FILLER. Velikovskii, A. A.; Gaichenko, L. N.; Lavrentovich, Ya. I. (Inst. of Nuclear Research, Kiev). Vysokomol. Soedin., Ser. B; 14: No. 11, 839-840(Nov 1972). (In Russian).

Glass has previously been used as a filler for radiation protection of plastic materials. The radiation damage to poly(methyl methacrylate) by 15 MR of $^{60}$Co-emitted $\gamma$ radiation was studied in samples containing powdered (30 $\mu$) aluminosilicate alkali-free glass in concentrations from 0 to about 80%. The molecular weight of the glass-free polymeric material (initially $2.5 \times 10^6$) fell to a value of $<1.2 \times 10^5$ as a result of the action of the ionizing radiation. In the case of the glass-filled polymer, the decrease in molecular weight was inversely proportional to the weight-percent of powdered glass added. (KSW)

**22257** THERMAL DECOMPOSITION OF IRRADIATED LEAD FORMATE. Ray, M. N.; Sinnarkar, N. D. (Univ. of Nagpur, India). J. Inorg. Nucl. Chem.; 35: No. 4, 1373-1375(Apr 1973).

The influence of $\gamma$-irradiation on the kinetics of thermal decomposition of lead formate is reported. Irradiation induced gray coloration in crystals. Color intensity increased with irradiation dose. The chemical damage was measured as formaldehyde produced by various irradiation doses. Data are presented on the kinetics of the thermal decomposition of the formate, unirradiated and irradiated. The activation energy was found to be 36.7 kcal/mole for unirradiated and 30.8 kcal/mole for irradiated material. The activation energy is appreciably affected by irradiation. (auth)

**22258** RADIATION-INDUCED MIXED-DISULFIDE FORMATION FROM CYSTAMINE AND ALIPHATIC DISULFIDES IN AQUEOUS SOLUTION. Owen, T. C.; Ellis, D. R. (Univ. of South Florida, Tampa). Radiat. Res.; 53: No. 1, 24-32(Jan 1973).

Solutions containing cystamine and dithiodiglycolic acid give, upon x-irradiation, the mixed-disulfide aminoethyldithioacetic acid. Yields increase with disulfide concentration, reach G values of 100 at 50 mM disulfide concentrations in air-saturated solutions, and undoubtedly reflect the occurrence of chain reactions. Radiolytic yields in deaerated solutions are double those in aerated solutions. A "plateau" phenomenon is observed; at a fixed cystamine concentration, mixed disulfide yields increase with increasing dithiodiglycolate concentration up to a certain point but do not increase significantly thereafter. This behavior indicates that dithiodiglycolate is much more reactive than cystamine in the chain-propagating step. Mixtures of cystamine with methyl and ethyl disulfides behave similarly. The reactive intermediate is unlikely to be a common species such as thiyl radical produced by interaction of both hydroxyl radicals and electrons with disulfide. Rather, two distinct species such as the disulfide anion-radical $(R-S-S-R)^-$ and cation-radical $(R-S-S-R)^+$ are indicated. (auth)

**22259** MTP INTERNATIONAL REVIEW OF SCIENCE. Volume 4. Magnetic Resonance. McDowell, C. A. (ed.). Physical Chemistry, Series One. Baltimore; University Park Press (1972). 371p. $24.50.

Research on magnetic resonance is reviewed from the standpoint of developments in areas in which there were significant advances during the five-year period, 1966 to 1971. Two chapters were indexed separately for NSA. The other eight chapters include discussions on nuclear spin relaxation in gases, NMR studies of molecular motion in solids, some applications of Moessbauer spectroscopy in chemistry and chemical physics, nuclear quadrupole resonance spectroscopy, carbon-13 nuclear spin relaxation, NMR and ESR in liquid crystals, electron resonance of gaseous free radicals, and optical detection of magnetic resonance in molecular triplet states. (JGB)

*For abstracts of individual chapters see: 22260 and 22261.*

**22260** ESR STUDY OF IRRADIATED ORGANIC CRYSTALS. Iwasaki, M. (Government Industrial Research Inst., Nagoya, Japan). pp 317-346 of MTP International Review of Science. Vol. 4. McDowell, C. A. (ed.). Baltimore; University Park Press (1972).

Papers published from 1966 to August, 1971 are reviewed. Most of the papers deal with the elucidation of the radiation-damage process in organic acids and related compounds. (164 references) (JGB)

**22261** BIOLOGICAL APPLICATIONS OF ELECTRON SPIN RESONANCE SPECTROSCOPY. Bolton, J. R. (Univ. of Western Ontario, London); Warden, J. T. pp 347-365 of MTP International Review of Science. Vol. 4. McDowell, C. A. (ed.). Baltimore; University Park Press (1972).

Literature published from Jan., 1966 to June, 1971 is surveyed. Topics discussed are tissues and cells, radiation biology, proteins containing transition metal ions, photosynthesis, spin labels, and molecules of biological interest. (139 references) (JGB)

# Radiochemistry and Nuclear Chemistry

## *Hot-Atom Chemistry*

**22262** REACTIONS OF ENERGETIC POSITRONIUM ATOMS IN OXIDIZING SOLUTIONS. Bartal, L. J.; Ache, H. J. (Virginia Polytechnic Inst. and State Univ., Blacksburg). Radiochim. Acta; 17: No. 4, 205-208(Nov 1972).

The lifetime spectra of positrons in aqueous solutions of Sn(IV), Hg(II), and Cu(II) salts were studied as a function of solute concentration. No changes in the lifetime, $\tau_1$, of the shortlived component in the time spectra were observed. The lifetime, $\tau_2$, of the longlived component was sharply reduced with solute concentration, becoming indistinguishable from the shortlived component at solute concentration of about 0.3–0.4 m. The decrease of $\tau_2$ was accompanied by a significant drop in the intensity, $I_2$, of the longlived component. The data are discussed in terms of a proposed "hot" positronium reaction. The rate constants for the interactions of thermal and "hot" Ps with the solute species were determined. (auth)

**22263** EFFECTS OF ADDITIVES ON THE CHEMICAL BEHAVIOR OF $^{60}$Co RECOIL SPECIES IN NEUTRON-IRRADIATED BENZENE SOLUTIONS OF TRIS(ACETYLACETONATO)COBALT (III). Tominaga, T.; Nishi, Y. (Tokyo Univ.). Bull. Chem. Soc. Jap.; 45: No. 10, 3213-3214(Oct 1972).

Previous investigations of the behavior of recoil species in organic solutions of metal chelate complexes indicated that some metal salts could work as effective scavengers to suppress thermal reactions and thus minimize the apparent retention in the irradiated solutions as well as in solutions of irradiated solids. The mechanism of these scavenging reactions was studied, and a probable mechanism for the scavenging effect by metal salts is proposed on the basis of recently obtained data concerning the change in the $^{60}$Co retention with the time in irradiated benzene solutions of Co(acac)$_3$ containing metal acetylacetonates as additives. (JGB)

**22264** FORMATION OF METHYL FLUORIDE BY FLUORINE ATOM CLEAVAGE OF TIN–CARBON BONDS IN TRIMETHYLTIN HYDRIDE AND TETRAMETHYLTIN. Cramer, J. A.; Iyer, R. S.; Rowland, F. S. (Univ. of California, Irvine). J. Amer. Chem. Soc.; 95: No. 2, 643-644 (24 Jan 1973).

Fluorine atoms react directly with $(CH_3)_3SnH$ and $(CH_3)_4Sn$ to cleave the Sn–C bond with the formation of methyl fluoride, as illustrated by $^{18}F + (CH_3)_3SnH \rightarrow CH_3{}^{18}F + (CH_3)_2\dot{S}nH$ (1). When $(CH_3)_3SnH$ or $(CH_3)_4Sn$ is added in low mole fraction, the product $CH_3{}^{18}F$ can be isolated and measured by radiogas chromatography with yields of about 5.6 and 8.3%, respectively, of total $^{18}$F. When $^{18}$F atoms are initially formed in an energetic state, a finite possibility exists that any particular reaction might have been initiated by the attack of a still-energetic $^{18}$F atom. The probability of such hot reactions should be approximately proportional to the mole fraction of substrate $(CH_3)_3SnH$ or $(CH_3)_4Sn$ mixed with $SF_6$. It was found, however, the $CH_3{}^{18}F$ yield actually increases with decreasing substrate concentration. The $CH_3{}^{18}F$ yield from $^{18}$F reaction with neopentane, on the other hand, displays the typical behavior of a "hot" product extrapolating to zero yields at high dilution in $SF_6$. The failure of the $CH_3{}^{18}F$ yield to diminish with decreasing alkyl tin concentration indicates that an overwhelmingly large fraction of the substitutions in (1) is initiated by essentially thermal $^{18}$F atoms. (DHM)

**22265** PREPARATION OF RADIOCARBON COMPOUNDS BY PYROLYSIS OF POLYMERS FORMED IN REACTOR-IRRADIATED PYRIDINE. Barakat, M. F.; Abdel-Ghany, M. (Atomic Energy Authority, Cairo). Kerntechnik; 15: No. 1, 24-26(Jan 1973).

The polymer found in reactor irradiated pyridine, containing the greater fraction of the generated $^{14}$C recoils, was thermally treated, and the degradation products were identified by radiogas chromatography. Pyrolysis was carried out using a flow reactor-type pyrolyser under different experimental conditions. In almost all cases, the polymer samples were completely transformed into a group of more simple volatile labeled products. Pyridine-$^{14}$C was obtained in remarkable yields. Some labeled methyl and ethyl pyridine derivatives together with benzene were also obtained but in relatively lower yields. The different factors affecting the possibility of using a pyrolysis step, following reactor irradiation of organic nitrogen compounds, as a means for preparing high specific activity radiocarbon compounds are discussed. (auth)

**22266** CHEMICAL STATES AND THERMAL ANNEALING OF THE $^{131}I$, $^{133}I$, AND $^{135}I$ FORMED BY $^{235}U$ FISSION DURING THERMAL NEUTRON IRRADIATION OF URANYL NITRATE AT ROOM AND LIQUID NITROGEN TEMPERATURES. Spiridon, S.; Calusaru, A. (Inst. of Atomic Physics, Bucharest). J. Inorg. Nucl. Chem.; 35: No. 3, 713-725(Mar 1973).

By means of an ion exchange method, using $KNO_3$ solutions as eluant, the species $IO_4^-$, $IO_3^-$, $I^-$, and $I^0$ were separated, after dissolution of uranyl nitrate crystals irradiated with thermal neutrons. The average percentages as iodide are: 35.22 for $^{131}I$, 41.82 for $^{133}I$, and 70.6 for $^{135}I$ when the uranyl nitrate crystals were irradiated at $10^{11}$ n $cm^{-2}$ $sec^{-1}$ (CT-2 channel of VVRS Reactor) and reactor channel temperature. With an $8.8 \times 10^8$ n $cm^{-2}$ $sec^{-1}$ (CT-3 channel) thermal neutron flux, the same average values are: 34.55 for $^{131}I$, 47.45 for $^{133}I$, and 88.33 for $^{135}I$ at reactor channel temperature, and 41.57, 50.48, 86.01 respectively at liquid nitrogen temperature. The dehydration temperature of the uranyl nitrate crystals before irradiation seems not to have an important effect on the initial values of the percentage of reduced form. In the case of the $^{131}I$ and $^{133}I$ isotopes (CT-2 channel) on heating the irradiated crystals at 100°C, oxidized forms increase during the first 2 to 4 hr. Then reduction becomes the predominant process and the red/ox ratio reaches a higher steady value for the samples pre-heated at 51°C, than those pre-heated at 100°C. On heating the irradiated crystals at 150°C, oxidation processes are always predominant for all three $^{131}I$, $^{133}I$, and $^{135}I$ isotopes. With the uranyl nitrate crystals irradiated in the CT-3 channel at liquid nitrogen temperature, thermal annealing at 100°C favors the reduction of both $^{131}I$ and $^{133}I$ forms. At 130°C, in the first 10 hr reduction of iodine occurs, but after this period oxidation becomes predominant. At 150°C only oxidation was observed. The $^{135}I$ isotope behaved differently. The species formed oxidise at all temperatures studied. (auth)

### *Properties of Radioactive Materials*

*Refer also to abstracts 22166, 22176, 22218, 22235, and 22485.*

**22267** (ARH-SA-148) PLUTONIUM DIOXIDE DISSOLUTION IN NITRIC/HYDROFLUORIC ACID MIXTURES: KINETICS AND MECHANISM. Barney, G. S. (Atlantic Richfield Hanford Co., Richland, Wash.). Jan 1973. Contract AT(45-1)-2130. 16p. (CONF-730111-1). Dep. NTIS.

From American Chemical Society winter meeting; Newport Beach, California, USA (28 Jan 1973).

The kinetics of the fluoride-catalyzed dissolution of powdered plutonium oxide in nitric acid were investigated over the concentration ranges of 2.0 to 12.0 molar nitric acid and 0.01 to 0.5 molar fluoride. The dissolution rate is controlled by diffusion of fluoride through a product layer on the surface of the solid $PuO_2$. The thickness of this layer increases as the reaction progresses and rapidly slows dissolution. The kinetics follow the parabolic rate law, $C = Kt^{1/2}$, where C is the concentration of dissolved Pu. The constant, K, is dependent on HF and $HNO_3$ concentrations, surface area, the diffusion coefficient, and temperature. The kinetic data can be explained on the premise that two parallel reactions occur, one forming the unreactive surface layer and inhibiting the reaction and the other forming the soluble plutonium species. (auth)

**22268** (CONF-730402-4) SPECTRAL STUDIES OF ACTINIDE IONS IN MOLTEN FLUORIDE SALTS. Young, J. P. (Oak Ridge National Lab., Tenn.). [nd]. 5p. Dep. NTIS.

From tenth rare earth research conference; Carefree, Arizona, USA (30 Apr 1973).

A facility for the spectral study of highly radioactive molten fluorides or highly radioactive solutions contained in a hot cell was developed. The spectrophotometer and related components are located outside the hot cell and only the sample and reference beam of light pass into and out of the radiation environment. Studies were made on the U(III) content in $LiF-BeF_2-ZrF_4-UF_4$ molten salt from MSR fuel sample. Results obtained were: no U(III) was initially seen; U(III) grew in by radiolytic means; and U(III) could be made or decomposed chemically in the highly radioactive sample. The spectra of Cm(III), Pa(IV), and Pu(III) in molten $LiF-BeF_2-ThF_4$ was also studied. (DHM)

**22269** (INR-1397) INVESTIGATIONS ON THE REDUCTION OF U(VI) → U(IV) IN THE NITRATE SOLUTIONS BY MEANS OF THE FORMIC AND Pt-CATALYZER. Szymanska, D. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 17p. (In Polish). Dep. NTIS (U. S. Sales Only) $3.00.

Conditions of the reduction of U(VI) → U(IV) in solutions of nitric acid–urea by means of formic acid were elaborated. The investigations were carried out on laboratory scale using static methods or dynamic methods in a continuous apparatus. The Pt-catalyzers for these processes were tested. The best catalytic property was shown by 5% $Pt/Al_2O_3$. A method of Pt-regeneration was elaborated. (auth)

**22270** (KFK-1573) DECONTAMINATION EXPERIMENTS ON METAL SURFACES WITH GAS AND STEAM FORMING REAGENTS. Kunze, S. (Kernforschungszentrum, Karlsruhe (West Germany)). Dec 1972. 39p. (In German). Dep. NTIS (U. S. Sales Only).

Comparative tests of the decontaminating action of nitric acid both in the vapor phase and in the liquid phase (at 60°C in boiling solution) were carried out. In the test series, stainless steel surfaces were investigated after conditioning by several methods (polishing, pickling, welding, or corroding in hot steam at 620°C and 1 atm for 500 hours). The samples were contaminated with weakly acidic, carrier-containing solutions of the isotopes $^{137}Cs$, $^{90}Sr/^{90}Y$, $^{144}Ce$, $^{60}Co$, $^{54}Mn$, $^{59}Fe$, and $^{51}Cr$ or mixtures thereof using three procedures (evaporation on the surface, submerging into a boiling solution, submerging under pressure), followed by a heat treatment at 200 or 450°C. The decontamination tests were done using 2-, 4-, 8-molar and azeotropic nitric acid with and without additions of surfactants. The decontamination results of 11 reactor materials contaminated in an autoclave were tabulated. Similar attempts to effect a decontamination by pickling between 100 and 400°C with hydrogen chloride, chlorine, nitrogen dioxide or mixtures thereof with nitrogen or air, led to lower decontamination factors despite the higher temperatures used. (auth)

**22271** (NIIAR-P-124) SPECTROPHOTOMETRIC STUDY OF ACTINIDE COMPLEXING AND SOLVATION. 5. Conditions of the U(IV) Hexanitrate Complex Formation. Rykov, A. G.; Andreichuk, N. N.; Vasil'ev, V. Ya. (Scientific Research Atomic Reactor Inst., Melekess (USSR)). 1971. 19p. (In Russian). INIS.

The yield of the hexanitrate complex of U(IV) is directly dependent on the tendency of the cation of the macrocomponent of the system to hydrate. It is proposed that the ultimate actinide (IV) complexes are formed according to the equation: $M(H_2O)x^{4+} + 6\ NO_3^- \rightleftharpoons M(NO_3)_6^{2-} + x\ H_2O$, and that the original form of U(IV), existing in perchlorate solutions, and the intermediate form, predominating in solutions with a $HNO_3$ concentration of 2 to 9 M, are hydrated isomers of the form $U(H_2O)_8^{4+}$. (tr-auth)

**22272** (ORO-1797-40) RESEARCH IN NUCLEAR CHEMISTRY. Progress Report for the Period June 1, 1972–May 31, 1973. Choppin, G. R. (Florida State Univ., Tallahassee. Dept. of Chemistry). 1972. Contract AT(40-1)-1797. 17p. Dep. NTIS $3.00.

**22273** (SZS-143, pp 24-30) EFFECT OF TYPE OF CONTAMINANT ON THE DECONTAMINATION OF PLASTICS. Boetius, I. Sep 1972. (In German).

In Radioactive wastes and decontamination.

Among others the effort for decontaminating a surface depends on the nature of contamination. For the tests which had hitherto been performed $^{90}Sr/^{90}Y$ was chosen since it is known from experience that the removal of $^{90}Sr/^{90}Y$ contamination is difficult. Up to now it was not known whether the application of $^{90}Sr/^{90}Y$ represents the least favorable conditions with regard to decontamination in the presence of other nuclides. Therefore the effect of further contaminants on the decontamination was tested. The studies were aimed at finding suitable conditions of contamination with regard to a testing procedure. It was ascertained that under certain conditions (pH, duration of contamination etc.) the removal of some radionuclides is more difficult than that of radionuclides contained in the primary coolant of a pressurized water reactor plant. (auth)

**22274** COMPLEXES OF URANYL $\beta$-DIKETONATES WITH SULPHOXIDES. Subramanian, M. S.; Pai, S. A.; Manchanda, V. K. (Bhabha Atomic Research Centre, Bombay). Aust. J. Chem.; 26: No. 1, 85-89(Jan 1973).

The proton magnetic resonance spectra of the synergistic complexes of uranyl $\beta$-diketonates with dihexyl sulphoxide as the neutral donor give a multiplet consisting of eight lines for the terminal methylene group protons adjacent to the sulphur atom of the sulphoxide and a triplet for the $\beta$-methylene protons. This conforms to an $ABX_2$ pattern arising as a result of nonequivalence of the two protons of the terminal methylene group as a result of steric hindrance to free rotation about the C–S bond. The presence of such restricted rotation has been adduced as evidence for a direct donor-metal bond. (auth)

**22275** AMBIGUOUS VARIABLE COMBINATIONS IN PLUTONIUM CHEMISTRY. Silver, G. L. (Monsanto Research Corp., Miamisburg, OH). Radiochem. Radioanal. Lett.; 13: No. 2, 101-108(5 Mar 1973).

Forbidden, tolerable, and ambiguous combinations of plutonium oxidation number with given fractions of hexavalent plutonium are graphically presented. A graph of ambiguous combinations of trivalent and hexavalent plutonium is also given, and the suggestion is made that there are some combinations of fractions of two valence states (e.g., hexavalent and tetravalent plutonium) which characterize plutonium solutions uniquely. (auth)

**22276** THIN-LAYER GEL CHROMATOGRAPHY OF POLYMERIC HYDROLYSIS PRODUCTS OF METAL IONS. Sinibaldi, M. (CNR, Rome). J. Chromatogr.; 76: No. 1, 280-284(7 Feb 1973).

The results obtained with the six metal ions Fe(III), Zr(IV), Al(III), La(III), Th(IV), and Ti(IV) show the possibilities of thin-layer gel filtration in the study of hydrolysis polymers. The presence of polymers can be detected in certain electrolyte solutions and a comparison of several ions can give a qualitative picture of the relative size and extent of polymer formation. (auth)

**22277** THORIUM TETRAFLUORIDE REACTION WITH HYDRAZINIUM(1+) FLUORIDE AND WITH ANHYDROUS HYDRAZINE. Glavic, P.; Slivnik, J.; Bole, A. (Nuklearni Inst. Jozef Stefan, Ljubljana, Yugoslavia). J. Inorg. Nucl. Chem.; 35: No. 2, 427-432(Feb 1973).

The systems $ThF_4-N_2H_5F-H_2O$ and $ThF_4-N_2H_4$ were investigated. The complex fluoride $(N_2H_5)_3ThF_7$ and the addition compounds $ThF_4 \cdot N_2H_4$ and $3ThF_4 \cdot 5N_2H_4$ were isolated. Ir spectra of the compounds are given as well as the x-ray powder diffraction data. The thermal decomposition of the complex fluoride is discussed. (auth)

**22278** OXIDE CHEMISTRY OF PROTACTINIUM IN MOLTEN FLUORIDES. Ross, R. G.; Bamberger, C. E.; Baes, C. F. (Oak Ridge National Lab., TN). J. Inorg. Nucl. Chem.; 35: No. 2, 433-449(Feb 1973).

The solubility behavior of an insoluble oxide phase of protactinium(V) was studied in molten $LiF-BeF_2-ThF_4$ (72-16-12 mole %)—the proposed solvent salt for the Molten Salt Breeder Reactor (MSBR)—as a function of temperature and redox potential. The stoichiometry of the precipitation indicated the O/Pa ratio to be 2.5 in this oxide phase; however, it could not be identified as $Pa_2O_5$. Moreover, the apparent entropy of solution of the precipitate, as indicated by the high temperature dependence of its solubility, is higher than expected for $Pa_2O_5$ by ~23 eu per mole of protactinium. For these reasons, this oxide phase is thought to be an addition compound $PaO_{2.5} \cdot nLiF$. It has such a low solubility—$\log (X_{PaF_5} \cdot X^{1/2}_{O^{2-}}) = 0.91 - 12.76\ (10^3/T)$—that the $PaF_5$ concentration in solution can be reduced by the addition of oxide to ~1 ppM at 550°C before $ThO_2$ saturation is reached. With $UF_4$ present at concentrations typical of an MSBR fuel (0.3 mole %), the $PaF_5$ concentration can be lowered to ~10 ppm (550°C) before a $UO_2$-rich solid solution with $ThO_2$ is precipitated. From equilibrium under a hydrogen atmosphere, which solubilizes the $Pa_2O_5$ phase as $PaF_4$, the equilibration quotient $Q = X_{PaF_5} P_{H_2}^{1/2}/X_{PaF_4} P_{HF}$ was estimated as $\log Q = -3.92 + 5.16\ (10^3/T)$. Entropies and formation free energies are estimated for $PaF_4$ and $PaF_5$ in solution and for the $Pa_2O_5$ phase. (auth)

**22279** LUMINESCENCE SPECTRA OF DEUTERATED HYDRATES OF URANYL NITRATE. Novitskii, G. G.; Umreiko, D. S.; Akimov, A. N.; Nikonovich, M. V. Zh. Prikl. Spektrosk.; 17: No. 6, 1004-1008(Dec 1972). (In Russian).

The luminescence spectra of a series of uranyl nitrate hydrates were investigated which had the formula type $[UO_2(NO_3)_2 \cdot 2H_2O] \cdot nD_2O[UO_2(NO_3)_2 \cdot 2D_2O] \cdot nH_2O$, where n = 0, 1, or 4. The fine structure of the spectra were interpreted, and conclusions were drawn regarding the stronger inner-sphere bonds of the $D_2O$ molecules with uranium as compared with the $H_2O$ molecules in these salts. (tr-auth)

**22280** METHOD OF PREPARATION OF AQUA SOLS CONTAINING URANIUM DIOXIDE. Smith, J. G. (to Grace (W. R.) and Co.). German Patent 1,592,414. 18 May 1972. 21p. (In German).

A process for the preparation of aqua sols containing uranium dioxide is described. The aqua sols may contain uranium dioxide and zirconium dioxide as well as uranium dioxide alone. (GF)

**22281** INTRACOMPLEX TRANSFER OF ENERGY BETWEEN IONS OF RARE EARTH ELEMENTS AND URANYL IONS IN SOLUTIONS AND GLASSES. Zhabotinskii, M. E.; Kraevskii, S. L.; Milyavskii, Yu. S.; Morozova, L. M.; Rudnitskii, Yu. P. Zh. prikl. Spektrosk.; 17: No. 6, 1023-1026(Dec 1972). (In Russian)

The excitation energy transfer rate between uranyl and rare earth element ions was measured in deuterated polyphosphoric acids with acceptor concentrations of from 0 to 1.25 moles/liter and at temperatures from 20 to 90°C. The viscosity of the solution increased rapidly with an increase in rare earth element concentration, evidence of structural transformations occurring within the solution. These data were used to evaluate the contribution of the mechanism of the dipole-dipole interaction of the ions which were intermixed by diffusion movements of the liquid, as well as the contribution of the mechanism of the type of encounter of the intracomplex transfer for the observed transfer rate. The respective roles of these two mechanisms were discussed. (tr-auth)

**22282** PROCEDURE FOR THE DEFLUORIDATION AND REDUCTION OF COMPOSITIONS CONTAINING URANIUM COMPOUNDS. Nivas, Y. (to General Electric Co.). German Patent 2,139,802. 2 Mar 1972. 15p. (In German).

A procedure is described for the defluoridation and control of the oxygen–metal ratio in a granulated composition containing uranium compounds, i.e. a composition containing uranium dioxide with fluoride additions, ammonium diuranate with fluoride additions, a mixture of uranium dioxide and plutonium dioxide with fluoride additions (the plutonium dioxide amounting up to 30 wt % of the mixture), or a mixture of uranium dioxide and gadolinium oxide with fluoride additions (the gadolinium oxide amounting to approximately 10 wt % of the mixture). The granulated composition is heated up to a temperature of approximately 400 to 800°C in an atmosphere containing, in the main, the components carbon dioxide and hydrogen. It is then cooled in a controlled atmosphere. (GF)

**22283** TRANSFER OF EXCITATION ENERGY IN URANYL SALT SOLUTIONS TO ADMIXED TETRAVALENT URANIUM AND RARE EARTH ELEMENTS. Skutov, I. K.; Umreiko, D. S. Zh. Prikl. Spektrosk.; 17: No. 6, 1027-1031(Dec 1972). (In Russian).

The intermolecular transfer of excitation energy of $UO_2^{2+}$ ion to added U(IV) and rare earth ions (REI) was investigated in various solvents at 77°K. A close dependency of the probability of the process on the nature of the solvent (light and heavy water, inorganic acids, alcohols etc.) was established. The kinetics of luminescence of mixed solvents and the substances indicated revealed a deviation from the law of luminescence attenuation. The energy transfer mechanism is discussed on the basis of the experimental data. The influence of chemical bond character on the probability of radiative and non-radiative transitions, and the peculiarities of the luminescence of these molecular systems were considered. (tr-auth)

**22284** STUDY OF THE NATURE OF IONIC SPECIES FORMED BY THE HYDROLYSIS OF THE HEXAVALENT URANIUM ION. Mavrodin Tarabic, M. (Physical Chemistry Center, Bucharest). Stud. Cercet. Chim.; 20: No. 9, 1035-1047(Sep 1972). (In Rumanian).

Previous studies of hexavalent uranium salts revealed that the $U^{6+}$ ion does not exist in aqueous solutions. The pertinent literature is analyzed. It is generally accepted that hexavalent U forms salts which contain the bivalent uranyl cation; the latter behaves like a strong electrolyte in solution. X-ray diffraction data of uranyl acetate, uranyl fluoride and various uranates and ir data of uranates in aqueous solutions of nitric and perchloric acids indicate that the $UO_2^{2+}$ ion has a linear structure. The 2 O atoms are held by a covalent bond at a distance of 1.91Å from the U atom. The schemes proposed to explain the behavior of the uranyl ion during hydrolysis are reviewed, mentioning the suggested existence of the mononuclear $UO_2OH^+$ and of complex polynuclear ions. It is concluded that current literature data do not clarify satisfactorily the hydrolysis of $U^{6+}$. (TTT)

**22285** REACTIONS OF HELIUM TRITIDE IONS WITH GASEOUS BICYCLO[n,1,0] ALKANES. Evidence for gaseous Bicycloalkylium Ions. Cacace, F.; Guarino, A.; Speranza, M. (Univ., Rome). J. Chem. Soc., Perkin Trans., II; No. 1, 66-69(1973).

The reactivity of the $HeT^+$ ion from the β-decay of molecular tritium towards bicyclo(2,1,0) pentane, bicyclo(3,1,0) hexane, and bicyclo(4,1,0) heptane was investigated in the gas phase. The radiogas chromatographic analysis of the labelled reaction products revealed in all the systems studied the formation of a tritiated hydrocarbon retaining the bicyclic structure of the starting substrate. This observation can be rationalized by postulating the intermediacy of the corresponding gaseous bicycloalkylium ion, formed via the exothermic triton transfer from the $HeT^+$ to the organic substrate, and suggests the occurrence of protonated bicycloalkanes in the gas phase. Owing to the considerable exothermicity of the electrophilic attack, a large fraction of the bicycloalkylium ions cannot be stabilized by collision in the pressure range investigated, 100 to 300 Torr, and undergoes various fragmentation and isomerization processes involving the cleavage of one or more C–C bonds. The mechanistic implications of these processes are discussed, and the gas-phase reactivity of the bicyclo[n,1,0] alkanes towards the strong Bronsted acid $HeT^+$ is compared with their behavior under the attack of milder electrophiles in solution. (auth)

**22286** EQUILIBRIUM AND KINETIC STUDIES OF THE REACTIONS BETWEEN NEPTUNIUM(III) AND THE COMPLEXES $(NH_3)_5RuOH_2^{3+}$ AND $(NH_3)_6Ru^{3+}$ IN AQUEOUS TRIFLUOROMETHANESULFONATE SOLUTIONS. Lavallee, D. K.; Lavallee, C.; Sullivan, J. C.; Deutsch, E. (Univ. of Chicago). Inorg. Chem.; 12: No. 3, 570-574(Mar 1973).

The second-order approach to equilibrium of the reaction Np(III) + Ru(III) = Np(IV) + Ru(II) was studied for $(NH_3)_6Ru^{3+}$ and $(NH_3)_5RuOH_2^{3+}$ in trifluoromethanesulfonate media. Neither the kinetic nor equilibrium parameters which govern these reactions exhibit a discernible acid dependence. For aquopentaammineruthenium(III) + Np(III)(25°C, I = 1.00 F), $Q = 0.062 \pm 0.008$, $k_f = 0.270 \pm 0.019$ $F^{-1}$ $sec^{-1}$, $\Delta H° = -8.7 \pm 0.2$ and $\Delta H_f^* = 4.24 \pm 0.25$ kcal/mol, and $\Delta S° = -34.8 \pm 0.8$ and $\Delta S_f^* = -46.9 \pm 0.9$ eu. For hexaammineruthenium(III) + Np(III) (25°, I = 0.50 F), $Q = 0.031 \pm 0.003$, $k_f = 0.305 \pm 0.036$ $F^{-1}$ $sec^{-1}$, $\Delta H° = -11.5 \pm 0.7$ and $\Delta H_f^* = 3.9 \pm 1.0$ kcal/mol, and $\Delta S° = -45.4 \pm 1.7$ and $\Delta S_f^* = -48.1 \pm 3.5$ eu. The reverse reaction of Np(IV) with aquopentaammineruthenium(II) was also followed directly, yielding an independent determination of $k_r$(25°C, I = 1.00 F) of $4.37 \pm 0.21$ $F^{-1}$ $sec^{-1}$. Experimentally determined equilibrium parameters are used to calculate values of the formal oxidation potential and $S°_{(2+)} - S°_{(3+)}$, for the $(NH_3)_5RuOH_2^{2+,3+}$ and $(NH_3)_6Ru^{2+,3+}$ couples of $-0.084 \pm 0.004$ V, $+17.5 \pm 1.1$ eu and $-0.066 \pm 0.003$ V, $+4.1 \pm 1.9$ eu, respectively. Kinetic parameters are discussed in terms of both the orthodox outer-sphere transition state and an unorthodox transition state in which ruthenium attains coordination number 7. The importance of $\Delta S^*$ in determining the rate of reaction between highly charged ions is pointed out. (auth)

**22287** METHOD OF PREPARATION OF AN ALKOXIDE OF ONE OF THE METALS HAFNIUM, ZIRCONIUM, AND THORIUM FROM A TETRAHALOGENIDE OF THE METAL. Hoch, M. German Patent 2,153,354. 25 May 1972. 25p. (In German).

A method is described for the preparation of an alkoxide of one of the metals hafnium, zirconium, and thorium from a tetrahalogenide of the metal. The metal tetrahalogenide is reacted with nonaqueous isopropyl alcohol with an alkali reagent having a pH value between 8 and 11 to form a metal tetraisopropoxide and the pH value is maintained during the reaction. If required the metal tetraisopropoxide is reacted with a secondary or tertiary alcohol (tertiary amyl alcohol) possessing at least 4 carbon atoms, in order to bring about the alcoholysis exchange with the metal isopropoxide to form a secondary or tertiary alkoxide of the metal. (GF)

**22288** VOLTAMMETRIC METHOD OF DETERMINING SODIUM OLEATE AND OLEIC ACID IN FLOTATION PROCESS SOLUTIONS. Mamakov, A. A.; Gorodetskii, Yu. S.; Drondina, R. V. Elektron. Obrab. Mater.; No. 5, 57-65(1970). (In Russian).

The effect of the surfactants oleic acid and sodium oleate on the magnitude of the limiting current for the reduction of, e.g., $Cd^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $UO_2^{2+}$, and $Tl^+$ were investigated by conventional and oscillographic polarography; the diffusion current decreased with increasing concentration of surfactant. The reasons for this are discussed, and it is shown that polarographic determination of the surfactants at levels of 30 μM to 3 mM is possible from the reduction of $Tl^+$ in an alkaline electrolyte. (Referativnyi Zh.)

**22289** PHOTOCHEMICAL REACTIONS IN ANALYTICAL CHEMISTRY. Communication 13. Reduction and Oxidation of Different Valent States of Neptunium Under the Ultraviolet Light in Nitric Acid Solutions. Nemodruk, A. A.; Bezrogova, E. V.; Ivanova, S. A.; Novikov, Yu. P. Zh. Anal. Khim.; 27: No. 12, 2414-2420(Dec 1972). (In Russian).

The behavior of neptunium in different valent states was studied under the irradiation of its $HNO_3$ solutions by a PRK-7 mercury-quartz lamp. Neptunium(V) does not change its valent state in 0.1 to 6 M $HNO_3$. Neptunium(IV) is oxidized and neptunium(VI) is reduced to neptunium(V). The irradiation markedly accelerates the transition of all the valent states of neptunium to neptunium(V) in the presence of large amounts of $H_2O_2$. Neptunium(IV) and neptunium(V) are oxidized to neptunium(VI) under the irradiation of $HNO_3$ solutions in the presence of urea. Methods are suggested for turning all the valent states of neptunium into neptunium(V) by the irradiation of their solutions in $HNO_3$ in the absence of $H_2O_2$ as well as in its presence. A method is also suggested for the photometric oxidation of all lower valent states of neptunium to neptunium(VI) by the irradiation of their $NHO_3$ solutions in the presence of urea. The kinetics of the oxidation of neptunium(IV) to neptunium(V) and neptunium(V) to neptunium(VI) was investigated. (auth)

**22290** THEORETICAL, PHYSICAL, AND CHEMICAL STUDIES OF OXOURANIUM(V) AND RELATED SPECIES. Durrett, D. G. Baton Rouge, LA; Louisiana State Univ., (1972). 214p. University Microfilms Order No. 73-2952.

Thesis (Ph. D.).

Work was undertaken to explain the observed spectral properties of the $UOCl_5^{2-}$ entity and to study the chemical properties of this unusual air-stable species. In order to explain the electronic spectrum of $(Et_4N)_2UOCl_5$, the theory of tetragonal $5f^1$ complexes was developed. A semiempirical calculation of the transitions of $UOCl_5^{2-}$ was carried out by beginning with the $5f^1$ energy levels of $UCl_6^-$ split by the $O_h$ crystal field and by spin-orbit coupling and then considering the effects of the lower symmetry field. In addition to the four band groups observed in the visible-near-I.R. region, two additional groups were sought (as a result of the theoretical predictions) and observed at lower energies. A new salt, $Cs_2UOCl_5$, was synthesized to aid in these spectral studies. An understanding of the electronic and ESR spectra of $UOX_5^{2-}$ and other U(V) compounds was gained from this study. A new salt, simpler preparative route to $(Et_4N)_2UOCl_5$ was developed; the method involved hydrolysis of the versatile $UCl_5 \cdot TCAC$ complex (TCAC = trichloroacryloyl chloride, $Cl_2C = CClCOCl$). In efforts to prepare additional compounds of the $UO^{3+}$ species, there were carried out reactions in which $UCl_5 \cdot TCAC$ was hydrolyzed in the presence of various ligands, and three new adducts of $UOCl_5^{2-}$ were prepared. These compounds are believed to contain free radicals complexed to U(V). Hydrolyses of two compounds of general formula $UCl_5 \cdot xL$ were performed; $(Et_4N)_2UOCl_5$ was the product in both cases. The direct reactions of $(Et_4N)_2UOCl_5$ with some ligands resulted in disproportionation of the U(V). The reaction of $(Et_4N)_2UOCl_5$ with phenazine resulted in the isolation of the unexpected free radical salt of phenazine(P), $\dot{P}H_2Cl$. Because of this fascinating result, analogous reactions were carried out with several phenazine-like compounds and with other uranium(V) compounds, and several stable solid free-radical salts were isolated. Studies were also conducted in order to understand the unusual reaction which produces the $\dot{P}H_2Cl$ radical. Due to importance of molybdenum(V) and of free radicals in biological systems, the above work was extended to Mo(V) compounds. Several new Mo(V) compounds were isolated, and free radical formation was found to occur in Mo(V)-phenazine reactions. (Diss. Abstr. Int., B)

**22291** GASEOUS MOLECULAR COMPLEXES $M_xM'_yCl_z$. Binnewies, M.; Schaefer, H. (Univ., Muenster, Ger.). Z. Anorg. Allg. Chem.; 395: No. 1, 77-81(Jan 1973). (In German).

A number of new complex molecules, including $TlPbCl_3$, $TlCdCl_3$, $TlThCl_5$, $Tl_2ThCl_6$, $TlUCl_5$, $TlU_2Cl_9$, $Tl_2UCl_6$, $CuThCl_5$, $Cu_2ThCl_6$, $CuUCl_5$, $Cu_2UCl_6$, $CdPbCl_4$, $BeFeCl_5$, $BeFe_2Cl_8$, $Be_2Fe_2Cl_{10}$, $Be_3Fe_2Cl_{12}$, $BeInCl_5$, $BeIn_2Cl_8$, $Be_2InCl_7$, $Be_3InCl_9$, $ZnInCl_5$, $SnInCl_5$, $BeZrCl_6$, $PbThCl_6$, $BeUCl_6$, $Be_2UCl_8$, $InUCl_8$, $In_2UCl_{10}$ and $ThUCl_8$, were observed by mass spectroscopy. A survey of the known molecules of this type is given. (auth)

**22292** MOESSBAUER STUDY OF THE CHEMICAL CONSEQUENCES OF THE $^{151}Sm(\beta^-)^{151}Eu$ DECAY IN VARIOUS SAMARIUM COMPOUNDS. Probst, C.; Kienle, P.; Luchner, K.; Wagner, F. E.; Zahn, U. (Technical Univ., Garching, Ger.). Radiochim. Acta; 18: No. 1, 19-23(Dec 1972).

The chemical consequences of the $^{151}Sm(\beta^-)^{151}Eu$ decay were studied by means of the Moessbauer effect of the 21.6 keV γ-rays of $^{151}Eu$ emitted from various $^{151}Sm$ compounds at 300, 77, and 4.2°K. In the emission spectra of sources of anhydrous $SmCl_3$, $(Sm_{.33}La_{.67})Cl_3$, and $(Sm_{.02}La_{.98})Cl_3$ the formation of both $Eu^{+3}$ and $Eu^{+2}$ is observed, whereas $Sm_2O_3$, $(Sm_{.02}Ce_{.98})O_2$, $Sm_2(C_2O_4)_3 \cdot 10\,H_2O$, and $(Sm_{.02}La_{.98})Cl_3 \cdot 6\,H_2O$ were found to emit only the $Eu^{3+}$ line within the limits of statistical error. These results are tentatively discussed in terms of a strong influence of the host-lattice structure on the chemical stability of $Eu^{+2}$ formed after the $^{151}Sm$ $\beta^-$ decay by a fast electronic recombination mechanism. (auth)

**22293** STABILITY OF PENTAVALENT PLUTONIUM. Silver, G. L. (Monsanto Research Corp., Miamisburg, OH). J. Inorg. Nucl. Chem.; 35: No. 4, 1369-1372(Apr 1973).

Methods are suggested for obtaining high equilibrium concentrations of unsequestered PU(V) in various circumstances which may occur experimentally. (auth)

**22294** THERMODYNAMICS OF URANIUM(VI) CHELATES OF DIHYDROXYBENZOIC ACIDS. Pant, A. N.; Soni, R. N.; Gupta, S. L. (Birla Inst. of Tech. and Science, Pilani, India). J. Inorg. Nucl. Chem.; 35: No. 4, 1390-1392(Apr 1973).

A thermodynamic study is reported on the interaction of U(VI) ions with dihydroxybenzoic acids, viz. o-pyrocatechuic acid, γ-resorcylic acid, and gentisic acid in aqueous medium. Stability constants of the chelates were evaluated at different ionic strengths by the molecular extinction coefficient method. The thermodynamic stability constants were then computed by extrapolating these values to zero ionic strength. The values thus obtained for uranium chelates with γ-resorcylic acid, o-pyrocatechuic acid, and gentisic acid are 3.29, 4.69, and 3.70, respectively. The thermodynamic functions for the formation of chelates from equilibrium constants at various temperatures were determined assuming the heat of reaction to be constant over the selected temperature range. Thus, the changes in Gibb's free energy were computed using van't Hoff isotherm, while the change in heat content and the changes in entropy were evaluated by using the following equations: $\Delta H = -R.S_1$, $\Delta S = (\Delta H - \Delta G/T)$ where $S_1$ is the slope of the linear plot of ln K vs 1/T. The values obtained are summarized. (auth)

**22295** STUDIES ON SOME METAL CHELATES OF 2′,4′-ACETOACETOXYLIDIDE. Taneja, A. D.; Srivastava, K. P. (Birla Inst. of Tech. and Science, Pilani, India). J. Inorg. Nucl. Chem.; 35: No. 4, 1397-1400(Apr 1973).

A report is presented on the isolation and characterization of complexes of 2′,4′-acetoacetoxylidide (AAXH) with copper(II), uranium(VI), and iron(III). All these complexes are soluble in ethanol, methanol, dioxane, acetonitrile, and other common organic solvents. The ir spectra of the ligand and the complexes were recorded. The molar conductance of the complexes in ethanol were determined with a conductivity meter. The transition energy and molar absorptivity were calculated by standard methods. The magnetic moment values of the chelates were determined by Gouy's magnetic balance. Proposals are put forward for the structures of the complexes. (auth)

**22296** HEXAGONAL AND ORTHORHOMBIC CRYSTAL STRUCTURES OF CALIFORNIUM TRICHLORIDE. Burns, J. H.; Peterson, J. R.; Baybarz, R. D. (Oak Ridge National Lab., TN). J. Inorg. Nucl. Chem.; 35: No. 4, 1171-1177(Apr 1973).

Californium trichloride was prepared in two crystalline modifications and single-crystal specimens of each were studied by x-ray diffraction. The hexagonal $UCl_3$-type crystal has unit-cell dimensions of a = 7.379(1) Å and c = 4.0900(5) Å and the orthorhombic $PuBr_3$-type, a = 3.869(2) Å, b = 11.748(7) Å and c = 8.561(4) Å. Structural parameters including anisotropic thermal motion were refined by the method of least squares. In the hexagonal form the Cf atom is 9-coordinated by six Cl atoms at 2.815(3) Å and three at 2.924(4) Å, while in the orthorhombic form the coordination is 8-fold with two Cf-Cl distances of 2.690(7) Å; four of 2.806(4) Å and two of 2.940(6) Å. An ionic radius of 0.932(3) Å was derived for the 6-coordinated $Cf^{3+}$ ion. (auth)

**22297** EXPERIMENTAL STUDY OF EQUILIBRIA IN THE $UO_3-CO_2-H_2O$ SYSTEM IN TEMPERATURE RANGE 25 TO 200°C. Sergeeva, E. I.; Nikitin, A. A.; Khodakovskii, I. L.; Naumov, G. B. (Inst. of Geochemistry and Analytical Chemistry, Moscow). Geokhimiya; No. 11, 1340-1350(Nov 1972). (In Russian).

The solubility of uranyl carbonate in aqueous carbon dioxide solutions in the 25 to 200°C range was determined. From these data the stability constants of carbonate complexes of uranyl: $UO_2CO_3^0$, $UO_2(CO_3)_2^{2-}$ and the values of $UO_2CO_{3(c)}$ activity products were calculated. Equilibrium constants of the reaction $UO_2CO_{3(c)} + H_2O_{(1)} = UO_2OH_{2(c)} + CO_{2(g)}$ were determined at 100, 150 and 200°C temperatures. The thermodynamical properties of the ($\Delta H^0_{298.15}$, $\Delta G^0_{f,T}$, $S^0_{298.15}$) products which are formed in the $UO_3-CO_2-H_2O$ system were calculated. The obtained data were used for the analysis of various factors (T, pH, $P_{CO_2}$) influencing the formation of carbonate complexes of uranyl in hydrothermal solutions and of the natural uranyl carbonate (mineral rutherfordine). (auth)

**22298** COMPOUNDS OF TECHNETIUM WITH A METAL–METAL BOND. Glinkina, M. I.; Kuzina, A. F.; Spitsyn, V. I. Zh. Neorg. Khim.; 18: No. 2, 403-407(Feb 1973). (In Russian).

Technetium compounds with a metal–metal bond were obtained by the reduction of an ammonium (potassium, cesium) pertechnetate solution in concentrated HCl by molecular $H_2$ under 20 atm (5 hr in an autoclave) at 170°C. Three salts were thus obtained having the following compositions: $K_8(Tc_2Cl_8)_3 \cdot 4H_2O$, $(NH_4)_8(Tc_2Cl_8)_3 \cdot 2H_2O$, and $Cs_8(Tc_2Cl_8)_3 \cdot 2H_2O$. Chemical analyses, valence state confirmations, pycnometric measurements, and absorption spectra determinations in the ir, uv, and visible regions were made. (KSW)

**22299** URANIUM TRIOXIDE–WATER SYSTEM. Hoekstra, H. R.; Siegel, S. (Argonne National Lab., IL). J. Inorg. Nucl. Chem.; 35: No. 3, 761-779(Mar 1973).

The uranium trioxide-water system was investigated in detail. The compounds prepared are $UO_3 \cdot 2H_2O$, $UO_3 \cdot 0.8H_2O$, α, β, and γ $UO_2(OH)_2$, and $U_3O_8(OH)_2$. The deuterated forms of these phases were also studied. Each of the compounds was characterized by x-ray diffraction, ir, Raman, and thermoanalytical methods. (auth)

**22300** STUDIES OF $UO_2$(II) COMPLEXES OF SUBSTITUTED SALICYLIC ACIDS. Jahagirdar, D. V.; Khanolkar, D. D. (Marathwada Univ., Aurangabad, India). J. Inorg. Nucl. Chem.; 35: No. 3, 921-930(Mar 1973).

The interactions of uranyl ion with salicylic acid and 3-bromo-, 3,5-dibromo-, 3,5-dichloro-, 4-hydroxy-, 5-hydroxy-, 3-nitro-, 5-nitro-, 3,5-dinitro-, 5-chloro-, and 4-iodo-salicylic acids were investigated by potentiometric titrations. The stability constants of complexes containing 1:1 and 1:2 ratios of $UO_2$(II) to ligand were estimated at 31°C and 0.1M($NaClO_4$) ionic strength in aqueous medium. The validity of the log K = apk + b relation is examined for these complexes. (auth)

**22301** MIXED LIGAND CHELATES OF URANYL ION. Khanolkar, V. D.; Jahagirdar, D. V.; Khanolkar, D. D. (Marathwada Univ., Aurangabad, India). J. Inorg. Nucl. Chem.; 35: No. 3, 931-940(Mar 1973).

To study the nature of the mixed complexes of $UO_2$(II) ion with bidentate carboxylic and phenolic acids, potentiometric titrations of $UO_2$(II) ion with various bidentate chelating agents were carried out. Evidence for the formation of 1:1 chelates of $UO_2$(II) with different ligands such as phthalic, adipic, succinic, 3:5-dinitrosalicylic, and 5-sulphosalicylic acids was found. A study of the $UO_2$(II) ion in the presence of equimolar concentrations of two ligands showed the formation of mixed ligand chelates containing 1:1:1 molar ratios of $UO_2$(II) and the two ligands. Formation constants of the mixed chelates are calculated and the chelates are shown to have formed in simultaneous equilibria. The lower values of stability constants of mixed ligand chelates than the sum of individual log stability constants of the first and second ligand are discussed. (auth)

**22302** COMPOSITION AND STABILITY OF URANYL COMPLEXES OF FURFURYL THIOL. Saxena, R. S.; Sheelwant, S. S. (Malaviya Regional Engineering Coll. Jaipur, India). J. Inorg. Nucl. Chem.; 35: No. 3, 941-947(Mar 1973).

Complex formation between uranyl ion and furfuryl thiol was studied by potentiometric and conductometric titration techniques in 50% ethanol. Two complexes, 1:1 and 1:2, are formed in the pH range 4.0 to 6.0 with considerable overlapping, the later complex being more pronounced. The log. $K_{stab}$ values of these complexes, in presence of 0.1 M $NaClO_4$, were determined at 15, 25, and 35°C and found to be 7.77, 7.37; 7.75, 7.34 and 7.73, 7.33, respectively. The values of ΔG, ΔH and ΔS calculated at 25°C are −20.50 kcal/mole, −1.56 kcal/mole, and +63.56 kcal/mole, respectively. (auth)

**22303** STABILITY OF TETRAVALENT BERKELIUM IN ACID SOLUTION AND THE ABSORPTION SPECTRA OF Bk(IV) AND Bk(III). Gutmacher, R. G.; Bode, D. D.; Lougheed, R. W.; Hulet, E. K. (Univ. of California, Livermore). J. Inorg. Nucl. Chem.; 35: No. 3, 979-994(Mar 1973).

The stability of Bk(IV) in sulfuric acid solutions was studied as a function of acid strength. To obtain the rate of reduction due to radiolysis, the absorption spectra were observed over a period of time. The dominant spectral feature of Bk(IV) in sulfuric acid is a strong charge-transfer band centered at 290 nm. The rate of reduction was inversely proportional to the acidity and closely paralleled the efficiency of production of $H_2O_2$ in that medium. The half-times ranged from 2.1 to 16.7 hr for 0.05M to 4.5M $H_2SO_4$ solutions. The stability of Bk(IV) in perchloric acid and in sodium pyrophosphate solutions was also investigated. Observations of the spectrum of Bk(III) were extended further into the ultraviolet to 200 nm and yielded nine new bands. Four strong bands are believed to be due to allowed transitions, placing the lowest level of the $5f^76d$ configuration at 41,300 $cm^{-1}$. (auth)

**22304** STRUCTURE OF URANIUM DIOXIDE SLUDGE OBTAINED BY THE ELECTROLYSIS OF A MIXTURE OF POTASSIUM, LITHIUM, AND URANYL CHLORIDES. Baraboshkin, A. N.; Puzakov, V. V.; Martem'yanova, Z. S. Tr. Inst. Elektrokhim., Akad. Nauk SSSR, Ural. Filial; No. 17, 108-117(1971). (In Russian).

The precipitate of $UO_2$ and its structure produced during the electrolysis of a mixture of molten salts: $3LiCl-2KCl-UO_2Cl_2$ were studied using various current densities and a temperature range of from 375 to 500°C. The $UO_2$ possessed a structure with a ⟨111⟩ axis, and its perfection was approached at 10 mA/cm$^2$ at 400°C. (KSW)

**22305** DECONTAMINATION OF ALUMINUM, STAINLESS STEEL, AND ALUMINUM STAINLESS-STEEL COUPLES. Zaric, M. M.; Matijasic, A. R. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Kerntechnik; 15: No. 1, 31-33(Jan 1973). (In German and English).

The efficiency of chromic-phosphoric acid, diammonium citrate, triammonium citrate, and tetrasodium salt of EDTA as decontaminating solutions for aluminum, stainless steel, and aluminum–stainless steel couples was studied using $^{60}$Co as the contaminant. The decontamination factors for both aluminum and stainless steel in chromic–phosphoric acid were very high. The decontamination factor for aluminum–stainless steel couples, in comparison to non-coupled metals, decreased. In all solutions tested, the increase in temperature led to an increase in the decontamination factors. (DHM)

## *Radioactive Waste Treatment*

*Refer also to abstracts 23009 and 23913.*

**22306** (JAERI-M–4803) APPLICATION OF IMPREGNATED CHARCOALS TO AIR MONITORING OF CHEMICAL PLANT. Naritomi, M.; Fukuda, S. (Japan Atomic Energy Research Inst., Tokyo). Apr 1972. 11p. NTIS (U. S. Sales Only).

In order to improve the performance of commercially available charcoal filter paper (Toyo Roshi type CP-20, 5 cm diameter, 0.2 cm thick, 50 w/o charcoal content) and charcoal cartridge (Toyo Roshi type CHC-30, 5 cm diameter, 2 cm thick, 30 mesh) for collecting airborne radioiodine released from chemical plants under conditions of high relative humidity and long sampling period, the charcoals were impregnated with triethylendiamine (TEDA), tin iodide ($SnI_2$), potassium iodide ($KI + I_2$), or potassium rhodanide (KSCN). The charcoals impregnated with TEDA or $SnI_2$ are greatly improved in their collecting performance as compared with the unimpregnated charcoals and the collection efficiencies of the impregnated charcoal cartridge and of the impregnated charcoal filter paper are maintained at more than 85% and 80% over the period of 14-hr sampling, respectively. It was found, however, that their collecting performance is deteriorated in the presence of chemically reactive gases such as $NO_X$, DBP. On the other hand, the charcoals impregnated with $KI_3$ or KSCN are little improved in their collecting performance. (auth)

**22307** (KFK–1651) RECOVERY OF TRANSPLUTONIUM ELEMENTS FROM FUEL REPROCESSING HIGH-LEVEL WASTE SOLUTIONS. Koch, G.; Kolarik, Z.; Haug, H.; Hild, W.; Drobnik, S. (Kernforschungszentrum, Karlsruhe (West Germany)). Nov 1972. 31p. (CONF-721107–5). Dep. NTIS (U. S. Sales Only).

From Symposium on the management of radioactive wastes from fuel reprocessing; Paris, France (27 Nov 1972).

A process for the recovery of americium and curium values from Purex-type high-level waste solutions is under development. The high-level waste is denitrated and the resulting fission product precipitate sent to HLW-solidification. The actinide–lanthanide fraction, which has been kept in solution, is separated by a HDEHP solvent extraction cycle. The Am/Cm is further purified by cation exchange. Results of "cold" flowsheet tests are reported. (auth)

**22308** (LA–5170) PERFORMANCE OF MULTIPLE HEPA FILTERS AGAINST PLUTONIUM AEROSOLS. Progress report, July 1-December 31, 1972. Ettinger, H. J.; Elder, J. C.; Gonzales, M. (Los Alamos Scientific Lab., N. Mex.). Jan 1973. Contract W-7405–eng–36. 27p. Dep. NTIS.

The field sampling program has been completed at four of the five original locations in three AEC plutonium processing plants. Size characteristics have been defined in terms of aerosol activity median aerodynamic diameter (amad) and geometric standard deviation ($\sigma_g$) using the Andersen eight-stage impactor. While size parameters show day to day variations, these can generally be classified within sufficiently narrow limits to permit development of typical criteria. Three locations yielded amad ranging from 0.9 to 4.0 $\mu$m; $\sigma_g$, from 1.5 to 4.0. The remaining site exhibited much higher activity concentrations and smaller amad (0.1 to 1.0 $\mu$m). The laboratory experimental system to test multiple HEPA filters was assembled. Its design will permit definition of series filter efficiency as a function of particle size using plutonium aerosols closely approximating those defined by the field sampling program. Initial tests of an aerosol generator, which nebulizes a water suspension of ball-milled $^{238}$Pu, resulted in an aerosol amad of 0.85 $\mu$m, $\sigma_g$ of 2.4, and activity concentration of $8 \times 10^{10}$ dpm/m$^3$. Selective ball-milling of the bulk powder, addition of anionic surfactant to the suspension, and ultrasonic agitation of the suspension provide control of size characteristics over the range of interest. Calculations to evaluate the possibility of $^{238}$Pu particles being sufficiently hot to damage the HEPA filter glass fibers indicate surface temperatures for $^{238}$Pu particles under 150 $\mu$m amad much lower than the softening point of borosilicate glass fibers in HEPA filters. (auth)

**22309** (SZS–133) METHODS FOR REMOVAL AND STORAGE OF RADIOACTIVE NOBLE GASES FROM OFF-GAS STREAMS OF NUCLEAR PLANTS. A Literature Survey. Schumann, F. (Staatliche Zentrale fuer Strahlenschutz, Berlin (East Germany)). Jul 1972. 36p. (In German). Dep. NTIS (U. S. Sales Only).

The literature is surveyed with regard to principal methods for separation of the noble fission gases Kr and Xe from gaseous effluents of nuclear plants and for converting them into a solid form. Operational experience gained from exhaust air-cleaning systems in nuclear power stations has shown that, by means of delay ducts or decay tanks, it is possible to reduce the concentration of noble fission gases originated during normal operation to such a degree that they can be discharged into the atmosphere. In many air-cleaning systems additional charcoal adsorbers are installed to meet the requirements arising from unusual operational conditions. In the future large amounts of long-lived $^{85}$Kr will be produced in large nuclear power stations and especially in reprocessing plants. Therefore efficient procedures are necessary for removal and concentration of this radionuclide. One of the methods to be considered is described taking a pilot plant for cleaning the off-gas of a reprocessing plant as an example. (auth)

**22310** (SZS-143) [RADIOACTIVE WASTES AND DECONTAMINATION]. (Staatliche Zentrale Fuer Strahlenschutz, Berlin (East Germany)). Sep 1972. 31p. (In German). Dep. NTIS (U. S. Sales Only).

A separate abstract was prepared for each of the five sections presented. (DHM)

*For abstracts of individual sections see: 22273, 22311, 22312, 23868, and 23913.*

**22311** (SZS-143, pp 1-6) TREATMENT OF BORIC ACID CONTAINING WASTE WATER IN A NUCLEAR POWER PLANT. Giesler, K.; Oertel, K. (VEB Kernkraftwerke, Greifswald, Ger.). Sep 1972. (In German).

In radioactive wastes and decontamination.

The amount of radioactive liquid effluents is of decisive importance for the operator of a boric-acid controlled nuclear plant. If the boric acid is not recovered its low solubility determines the waste water volume which must be temporarly stored and, if necessary, solidified. A procedure is described which was developed and large-scale tested at VEB KKW Rheinsberg. By this procedure the boric acid is converted into sodium pentaborate so that the waste water can be concentrated up to 180 g $H_3BO_3$/l. Literature data on solubility are discussed and operating experience is evaluated. (auth)

**22312** (SZS-143, pp 7) CEMENTATION OF BORATE CONTAINING EVAPORATOR RESIDUES FROM NUCLEAR POWER PLANTS CONSIDERING FINAL STORAGE IN SALT MINES. Reiter, E. Sep 1972. (In German).

In radioactive wastes and decontamination.

Latest results of studies on physico-mechanical and technological principles of solidification of borate containing evaporator residues by cementation in salt mines are presented considering especially the effect of various residue compositions on the behavior of hydraulic binding agents and additives as well as the effect of brine on the solidification process, the volume stability and the leaching behavior of the cement blocks. Conclusions are drawn and recommendations are given with regard to the applicability of the solidification of borate containing evaporator residues from nuclear power plants by cementation, the selection of feasible binding agents and additives, the determination of the optimum mixture ratio and the development of cementation technology in a salt mine. (auth)

**22313** (SZS–144) DECONTAMINATION OF RADIOIODIDE CONTAINING WATERS WITH SYNTHETIC ORGANIC ION-EXCHANGE RESINS. Alm, M.; Johannsen, K.-H. (Staatliche Zentrale Fuer Strahlenschutz, Berlin (East Germany)). Oct 1972. 24p. (In German). Dep. NTIS (U. S. Sales Only).

The decontamination of radioiodide containing waters was studied with Wofatit SBK and Wofatit AD 41 anion exchange resins and Wofatit ES, adsorption resin. To evaluate the applicability of these three resins, their effectiveness in decontaminating radioiodide containing surface waters was investigated. Their regeneration behavior to conventional regenerating agents was also studied. The effect of pH value, foreign ions, and iodide concentration, as well as the equilibrium of iodide between resin and aqueous phase was studied. The data obtained are discussed with regard to the nature of iodine sorption and the usefulness of the exchangers for the treatment of radioiodide containing waters. (auth)

**22314** RADIOACTIVE WASTE: A SOURCE FOR VALUABLE SUBSTANCES. Keller, C. Naturwiss. Rundsch.; 25: No. 6, 225-226(1972). (In German).

A brief survey is presented on the valuable elements neptunium, americium, curium, technetium, and noble metals which are still contained in the waste solutions from reprocessing plants, as well as their manifold suitability. (INIS)

## *Radioisotope Production*

**22315** (CONF-730402-1) RAPID LANTHANIDE AND ACTINIDE SEPARATIONS WITH PRESSURIZED ION EXCHANGE CHROMATOGRAPHY. Campbell, D. O. (Oak Ridge National Lab., Tenn.). [nd]. 10p. Dep. NTIS.

From 10th rare earth research conference; Carefree, Arizona, USA (30 Apr 1973).

Two sets of experiments were conducted in an effort to optimize the conditions for the separation of rare earths and actinides by pressurized ion exchange. In one a gradient elution was used to separate all the rare earths with the goal being separation of macro amounts of all fifteen elements in about 1 hr. In the second experiment the separation of the seven rare earths from Tb to Pr was studied with a constant eluant concentration so that variables other than gradient could be optimized. Results show that under the conditions of the experiments quantitative separation is provided with a column of 30 cm in times approaching 1 hr. Results also indicate that the use of smaller-sized resin, about 10 $\mu$, should yield good separations with columns only about 10 cm long and with length to diameter ratios as low as 10. Pressure drops would be reasonable with flow rates of 10 to 20 ml $cm^{-2}$ $min^{-1}$. Production rates should exceed 100 g of rare earth per day per liter of resin. (DHM)

**22316** (JAERI-M-4785) PROGRESS REPORT IN THE PRODUCTION OF RADIOISOTOPES FOR FISCAL 1970. (Japan Atomic Energy Research Inst., Tokyo). Mar 1972. 81p. (In Japanese). NTIS (U. S. Sales Only).

Activities and distinctive achievements in the Division of Production, Radioisotope Centre, are described for the period of April 1970 to March 1971. The total amounts of radioisotopes shipped out during the period were 1.23 times as large as in fiscal 1969. In the production of radioisotopes, that of $^{192}$Ir radiation-sources with JMTR was started. Production methods were developed for colloidal $^{198}$Au, high specific-activity $^{65}$Zn by Szilard-Chalmer's effect, and short-lived fission products by means of successive cation exchanges. The development of a BOB 7 Code Series for computational analysis of $\gamma$-ray spectra and a phenomenological analysis of the nuclear fission of moderately excited nuclei are also reported. (auth)

**22317** (JINR-P6-6923) PRODUCTION OF THE RADIOCHEMICALLY PURE RADON SAMPLES. Kolachkovskii, A.; Norseev, Yu. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1973. 9p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

Use of gas chromatography on artificial zeolites of the type of molecular screens 5 Å permits the production of radiochemically pure radon samples by extracting them from the gaseous products of fission and splitting. (auth)

**22318** (RFP-1947) LIQUID-LIQUID EXTRACTION OF AMERICIUM FROM MOLTEN PLUTONIUM METAL. Moseley, J. D.; Knighton, J. B. (Dow Chemical U.S.A., Golden, Colo. Rocky Flats Div.). 4 Aug 1972. 12p. (CONF-720984-1). Dep. NTIS.

Molten plutonium metal is equilibrated with a molten salt and the americium is preferentially extracted into the salt. The molten salt used is NaCl-50% KCl eutectic composition, and magnesium chloride is added to act as an oxidant in the reaction. The molten salt extraction of americium from plutonium metal is a production process at the Rocky Flats Facility. (DHM)

**22319** CHEMIESE SKEIDING VIR DIE PRODUKSIE VAN DRAERVRYE SIKLOTRON RADIO-ISOTOPE. (Chemical Procedures for the Production of Carrier-free Cyclotron-Produced Radioisotopes). Van der Merwe, M. J. Pretoria; Univ. of Pretoria (1971). 50p. Atomic Energy Board, Pelindaba, S. Afr.

Separation procedures were developed for the carrier-free separation of $^{109}$Cd from silver, $^{196}$Au from platinum and $^{67}$Ga from zinc and iron. The separation of $^{109}$Cd from the silver matrix is a great improvement on the existing method not only as to the purity of the final product but also to the duration of the separation. The iron decontamination, when separating $^{67}$Ga from zinc is very effective, while the procedure for $^{196}$Au production is very suitable for the separation of curie amounts of $^{196}$Au. The disadvantage of this method is that the destruction of the ion exchange by the hydrochloric acid-acetone solvent contaminates the final product. Gold-196 is used in sand movement studies, while $^{55}$Fe and $^{109}$Cd are supplied to overseas firms for the manufacture of x-ray fluorescence sources. The separation of $^{123}$I from antimony, $^{52}$Fe from chromium, and $^{55}$Fe from manganese was also undertaken. The medical isotopes, $^{67}$Ga and $^{123}$I, are supplied respectively on a weekly and bi-weekly basis to hospitals, while $^{52}$Fe is produced upon request. All these separation procedures are successfully applied to the routine production of radioisotopes. (auth)

**22320** PREPARATION OF THIN FILMS OF $^{147}$Pm BY MEANS OF CO-ELECTRODEPOSITION. Parker, W. C.; Ong, A. S.; Schall, E. (Instituto Militar de Engenharia, Rio de Janeiro). Radiochem. Radioanal. Lett.; 13: No. 2, 89-94(5 Mar 1973).

The preparation of thin films of $^{147}$Pm by means of coelectrodeposition is described. Codeposited with neodymium from alcohol solutions yields of better than 80% can be obtained for a four hr run. Because of their excellent adhesion and temperature stability properties such films are ideal for use as ionization sources in electron capture detectors as used in gas chromatography. The films can be operated at temperatures above 500°C and are unaffected by halogen or chlorine gas. (auth)

**22321** METHOD AND DEVICE FOR THE PREPARATION OF RADIOACTIVE MATERIAL. Smith, E. M.; Hupf, H. B. German Patent 2, 152,794. 4 May 1972. 13p. (In German).

An isotope generator is described for $^{99m}$Tc for use in nuclear medicine. The initial product is $Na_2MoO_4$ with the mother isotope $^{99m}$Mo. The daughter isotope $^{99m}$Tc is separated by sublimation as $Tc_2O_7$ which can be eluted by a suitable eluting agent, converting it to pertechnetate. The generator consists of a tubular element with a sintered glass disk for the reception of the mother compound and a heating device surrounding it. During the sublimation process a stream of air is passed through the tube which transports the radioactive sublimation product to a cooler part of the tube or to a special collecting container where it can be dissolved under sterile conditions. (GF)

**22322** PREPARATION AND APPLICATION OF TRANSURANIUM ELEMENTS. Keller, C. (Kernforschungszentrum, Karlsruhe, Ger.). Naturwiss. Rundsch.; 25: No. 9, 331-342 (1972). (In German).

A general review is presented on the production and synthesis of the transuranium elements in which context the different possibilities for the buildup, production in nuclear reactors, by means of nuclear explosions, or by means of nuclear reactions with heavy ions, are demonstrated using some practical examples. In addition, the efforts in producing superheavy elements in the region of doubly magic nuclei with Z = 114 and 164 with the help of destined heavy-ion reactions are outlined. Furthermore practical applications of transuranium elements as fuels, as energy or radiation sources in various fields of research and technology are reported. (INIS)

**22323** PRIMARY TARGET FOR THE PRODUCTION OF FISSION PRODUCTS IN A NUCLEAR REACTOR AND PROCEDURE FOR ITS PREPARATION. Arino, H.; Cosolito, F. J.; George, K. D.; Thornton, A. K. (to Union Carbide Corp.). German Patent 2,164, 268. 29 Jun 1972. 20p. (In German).

A particular irradiation target was developed with the aim of producing $^{99}$Mo of high purity by fission of uranium or plutonium in a nuclear reactor. It consists of a capsular cylindric metal container; closed at its upper and lower end and provided with a port to enable access to the inner part, and of a layer of fissionable material on the inner cylinder wall, which has been thinly and uniformly faced by an electrolytic method. (GF)

**22324** SOLVENT EXTRACTION OF TRANSPLUTONIUM ELEMENTS BY THE MIXTURES OF TRI-N-OCTYLAMINE WITH NEUTRAL EXTRACTANTS FROM NITRATE SOLUTIONS. Chmutova, M. K.; Myasoedov, B. F.; Spivakov, B. Ya.; Kochetkova, N. E.; Zolotov, Yu. A. (Inst. of Geochemistry and Analytical Chemistry, Moscow). J. Inorg. Nucl. Chem.; 35: No. 4, 1317-1326(Apr 1973).

Using $^{241}$Am, $^{244}$Cm, $^{250-252}$Cf, and $^{152}$Eu the solvent extraction of the trivalent transplutonium elements and europium from nitrate solutions into mixtures of tri-n-octylamine (TOA) with tri-n-butyl phosphate (TBP) and other neutral extractants in different solvents was studied. A synergistic effect was found for mixtures of TOA with TBP, tri-n-octylphosphine oxide, and triphenylphosphine oxide. The influence of different factors on the synergistic effect in mixtures of TOA with TBP was studied. Possible reasons for the synergistic effect are discussed. It is suggested that the effect is due to the formation of mixed anionic complexes of the metals containing coordinated TBP molecules and $NO_3^-$-groups. (auth)

**22325** STUDY OF CONDITIONS FOR THE PREPARATION AND UTILIZATION OF $^{68}$Ge−$^{68}$Ga GENERATOR. Kopecky, P.; Mudrova, B.; Svoboda, K. (Inst. of Nuclear Research, Rez, Czech.). Int. J. Appl. Radiat. Isotop.; 24: No. 2, 73-80(Feb 1973).

Some questions of the adsorption of germanium and gallium on alumina were investigated. The effect of pH of the aqueous phase and the concentration of germanium carrier on the adsorption as well as the kinetics and the reversibility of adsorption were studied. Examinations of $^{68}$Ge−$^{68}$Ga generators prepared on the basis of the results obtained are also described. Experimental results demonstrating the effect of a flow rate on the yield of $^{68}$Ga elution and on the shape of the elution curve are shown. (auth)

## *Reactor Fuel Reprocessing*

*Refer also to abstracts 22131, 22246, 22483, and 22495.*

**22326** (ANL−7969) DEVELOPMENT AND PERFORMANCE OF A HIGH SPEED ANNULAR CENTRIFUGAL CONTACTOR. Bernstein, G. J.; Grosvenor, D. E.; Lenc, J. F.; Levitz, N. M. (Argonne National Lab., Ill). Jan 1973. Contract W-7405-eng-38. 24p. Dep. NTIS $4.00.

A centrifugal contactor was developed for the solvent extraction processing of nuclear fuels. The novel aspect is that aqueous and organic solutions are fed directly into the annulus between the hollow 4-in.-dia rotor and the casing and are mixed by skin friction as they flow downward. This design eliminates the mixing chamber, mixing paddle, and injection nozzle employed in the centrifugal contactor design developed at the AEC's Savannah River (SR) Plant. High throughput is achieved by the high length-to-diameter (L/D) ratio combined with high operating speed (to 3500 rpm). Separating capacities with synthetic Purex-type solutions [i.e., 0.5M nitric acid and 30% tributyl phosphate (TBP) in n-dodecane diluent] ranged from about 5 gpm at 2000 rpm to about 15 gpm at 3500 rpm. Essentially 100% stage efficiency was demonstrated in extraction and stripping tests with uranium as the solute. Mechanical performance was very good throughout the tests. (auth)

**22327** (DOCKET-50268-40) MIDWEST FUEL RECOVERY PLANT. Amendment 33, Extension of Construction Completion Date. (General Electric Co., San Jose, Calif. Nuclear Energy Div.). 27 Feb 1973. 5p. Dep. NTIS.

An extension of construction completion date is requested for the purpose of completing the pre-operational testing prior to issuance of the requested operation license. An alternative is suggested that since the safety and environmental reviews have been completed and the notice of intent to license has been issued, the pre-operational verification testing is at a status that would permit the issuance of an operating license prior to expiration of the current construction completion date. The operating license would be appropriately conditioned to require Commission review and acceptance of the pre-operational test results prior to authorizing processing of the enriched and irradiated fuels. (DHM)

**22328** (INIS-mf-88) RESEARCH ON FUEL CYCLES OF NUCLEAR POWER STATIONS CARRIED OUT IN THE CHEMISTRY DEPARTMENT OF THE INSTITUTE OF NUCLEAR RESEARCH. Havelka, S.; Berak, L.; Kourim, V.; Peka, I.; Podest, M.; Sraler, V. 13p. (In Czech). (CONF-701214-5). INIS.

From fifth conference on nuclear power; Piestany, Czechoslovakia (1 Dec 1970).

The activities of the chemistry department of the Institute of Nuclear Research are reported. These include research on ceramic nuclear fuels, irradiated fuel processing (the PUREX process and the fluoride process), and treatment of waste from irradiated fuel processing. For each problem, a brief description is given of the current status and of the results obtained so far at the Institute. (INIS)

**22329** (INR−1429) URANIUM SORPTION FROM SULPHATE SOLUTIONS ON THE WOFATIT HS 115/1 AND HS 115/2 ANION EXCHANGE RESINS. Majchrzak, K.; Olech, B. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 22p. (In Polish). Dep. NTIS (U. S. Sales Only) $3.25.

The usefulness of Wofatit HS 115/1 and 115/2 anion exchange resins for uranium separation from sulfate leach liquors was investigated. To facilitate the evaluation of these resins, similar experiments with Duolite A 101 D resin were carried out. The parameters of uranium sorption and elution and the purity of uranium concentrates, precipitated from the eluates, were established. The particle size of the examined resins was also investigated. It has been stated that the process economy is determined by the uranium losses in the sorption process and the elution efficiency. The highest elution efficiency was obtained with Wofatit HS 115/2 resin which gives also the lowest uranium losses. (auth)

**22330** (NP−19586) PUBLIC OPINION AND WESTCOAST PLANNING. A Study of Public Opinion About the Planned Siting of a Fuel Reprocessing Plant to Sannaes in Northern Bohuslaen. Fuerst, G. (Goteborg Univ. (Sweden). Sociologiska Institutionen). Aug 1971. 153p. (In Swedish). Dep. NTIS (U. S. Sales Only).

The public opinion about the planned siting of a nuclear fuel reprocessing plant in Sannäs in Northern Bohuslän was studied. The opinion seemed to be a critical attitude towards the peaceful use of nuclear energy initially, but later it was shown to originate from quite different questions. Siting of an industry in Northern Bohuslän pointed out problems of urbanization, conflicts between industry and tourism, problems of employment, and environmental interests. The course of events is presented. Information from newspapers and information meetings is summarized. Generally, the possibility of citizens having an impact on decisions by experts and authorities is discussed. Facts and statistics are given in 14 appendices. (Sweden)

**22331** (PNCT−841-71-34) NEPTUNIUM RECOVERY IN THE PUREX PROCESS. I. Study on the Distribution of Np(IV) and Np(VI) in the System TBP−U−$HNO_3$. Tsuboya, T.; Nemoto, S.; Hoshino, T. (Power Reactor and Nuclear Fuel Development Corp., Tokai (Japan)). Oct 1971. 38p. NTIS (U. S. Sales Only).

From the results of batchwise extraction measurements of Np(IV) and Np(VI) in the systems 10, 20, and 30% (v/v) TBP (Tri-n-butyl phosphate, diluent)−U−$HNO_3$, it was shown that linear relations lay between log $(E_{Np}/(TBP)_0^2)$ and log $(NO_3)_{aq}$, where $E_{Np}$; the extraction coefficient of Np, $(TBP)_0$; the free TBP concentration, $(NO_3)_{aq}$; total nitrate concentration in the aqueous phase. Each thermodynamical equilibrium constant of Np(IV) or Np(VI) in these extraction systems, Ka, was found to be 0.66 or 7.4, respectively. Each $E_{Np}/E_U$ ratio was almost constant between 0.2 and 3 M $NO_3$. (auth)

**22332** (RT/CHI−(72)13) SEPARATION OF RARE EARTHS FROM A MATRIX OF MIXED OXIDES OF URANIUM AND THORIUM BY MEANS OF SOLVENT EXTRACTION. Pompei, V.; Canonico, A.; Mastrofrancesco, M. (Comitato Nazionale Per L'Energia Nucleare, Rome (Italy)). 10 Jul 1972. 54p. (In Italian). Dep. NTIS (U. S. Sales Only). $4.75.

A simple method for the quantitative separation of rare earths from their nitric solutions is described. The procedure is based on the solvent extraction of the rare earths. A simultaneous separation from the lanthanides of the common element impurities present in the mixed thorium uranium oxides was accomplished. The method fulfills the requirements of accuracy, simplicity, and speed necessary for use in the routine determinations. It assures a good separation and purification of rare earths from thorium, uranium, corrosion, and fission products and the apparatus can be easily remotized. (auth)

**22333** METHOD OF REMOVAL OF METALLIC FISSION PRODUCTS FROM SPENT ACTINIDE FUEL ELEMENTS. Anderson, R. N.; Parlee, N. A. (German Patent 2,064,983. 18 May 1972.

The method for the removal of metallic fission product impurities from spent actinide fuel elements is described thus characterized in that the spent fuel element of uranium or uranium oxide is added to a solution medium of fused metal (tin). This does not easily form nitrides and is able to dissolve the actinide as well as the impurities which are present in metallic form. The composition obtained is put into an inert fire-proof graphite boiler and is nitrated in a nitrogen atmosphere which is mainly free from other noninert gases. The temperature and the pressure during nitration is so adjusted that the actinite, in form of actinide nitride, precipitates out of the composition, whereas the metallic fission product impurities remain in the fused metal. The precipitated actinide nitride (uranium nitride) is separated from the remaining fused metal and converted to uranium, in particular uranium oxide. (GS)

**22334** EQUIPMENT FOR THE CHLORINATING VOLATILIZATION OF THORIUM AND URANIUM. Laser, M.; Bohnenstingl, J.; Fischer, E. (to Kernforschungsanlage Juelich GmbH). German Patent 2,040,686. 24 Feb 1972. 11p. (In German).

Equipment is described for the improvement of the procedure for the chlorinating volatilization of uranium and thorium from ground fuel and breeder elements prepared by using graphite. Equipment consisting of a reaction vessel with a condenser at the outlet side was modified so as to be able to operate continuously and to condense the uranium and thorium chlorides either in fractionated or in nonfractionated form, according to requirements. (GS)

**22335** METHOD FOR IMPROVED FISSION PRODUCT SEPARATION IN THE AQUEOUS REPROCESSING OF SPENT NUCLEAR FUELS. Schaefer, L.; Wojtech, B. (to Farbwerke Hoechst AG). German Patent 2,057,760. 25 May 1972. 12p. (In German).

A method for the improved separation of fission products with the aqueous reprocessing of uranium or thorium from spent fuels which may also contain plutonium is described. A nitrate feeder solution of the fuels is prepared and thorium and uranium salts are extracted from the aqueous nitrate containing solution using an organic extracting agent. The fission product part is washed from the organic phase in a several step fluid-fluid counter current extraction system consisting of an extracting section and a washing section. To remove the fission products aqueous solution of ethylenediaminetetraacetic acid, in particular its salts, is added to the washings of the extraction system. The washings containing ethylenediaminetetraacetic acid resulting from the final stage of the washing process is led back together with the feeder solution into one of the two final steps of the extraction process, whilst tributyl phosphate solution is added to the other final stage. The concentration of the ethylenediaminetetraacetic acid in the washing solution was between 0.001 and 0.3 mol/1, preferably between 0.01 and 0.1 mol/1. (GF)

**22336** METHOD FOR THE RECOVERY OF URANIUM AS URANIUM HEXAFLUORIDE FROM SPENT NUCLEAR FUELS AND/OR BREEDER MATERIALS CONTAINING URANIUM AND THORIUM. Kreutz, R.; Kuhrt, W.; Massonne, J. (to Kali-Chemie AG). German Patent 2,040,426. 17 Feb 1972. 10p. (In German).

In the chlorination reprocessing of nuclear fuels and breeder elements containing U and Th, the chlorides fed over in the form of gases at 900 to 1,200°C are condensed. According to the process, the condensate is reacted with hydrogen fluoride and the solid uranium–thorium fluoride mixture is then converted with elemental fluorine to volatile uranium hexafluoride. The two conversions take place within very definite temperature ranges in the presence of an inert gas and a solid diluting agent. The volatile uranium hexafluoride is collected and separated from the rest of the gases by sorption-desorption on sodium fluoride and is condensed in several cooling traps between −10 and −80°C and then fractionally distilled from the remaining impurities. (GF)

**22337** MODEL EXPERIMENTS ON CHEMICAL REPROCESSING OF NUCLEAR FUELS BY A CHLORIDE VOLATILIZATION PROCESS. Part 5. A Technique for Quantitative Separation of Uranium and Fission Product Chlorides from Gas Phase. Stahlberg, R.; Krause, F.; Reinhard, G. (Zentralinstitut fuer Kernforschung, Rossendorf, Ger.). Kernenergie; 15: No. 7, 230-231(Jul 1972). (In German).

A favorable technological version for quantitative separation of uranium chlorides and fission product chlorides from gas phase is described. The reaction gases pass through a catching liquid ($CCl_4$) and then flow through a fixed bed (or a bulk layer) continuously washed out by the $CCl_4$ reflux. The experimental results for $UCl_5-UCl_6$ and $UCl_5-UCl_6-MoCl_5-NbCl_5$ mixtures are elucidated. Simple and comparatively reliable results are presented for a technological concept of processing remotely controlled under radioactive conditions. (auth)

**22338** REPROCESSING METHOD FOR FUEL AND/OR BREEDER ELEMENTS. Merz, E.; Kaiser, G.; Riedel, H. J.; Laser, M. (to Kernforschungsanlage). German Patent 1,592,129. 9 Mar 1972. 12p. (In German).

The reprocessing procedure for fuel and/or breeder elements (uranium–thorium mixed oxide or uranium–thorium mixed carbide) in which the fuel or breeder element after the removal of claddings or coatings, is dissolved in a pyrosulfate fusion. Solid alkali hydroxide is added to the fusion until the alkali reaction takes place, from which in a further stage of the process, a mixture of thorium oxide and alkali uranates precipitate and can be separated. In the presence of mixed carbides these can be dissolved in an oxidizing alkali fusion ($NaOH + Na_2O_2$, $Na_2CO_3 + K_2CO_3$). In both cases the yielded precipitates are fluorinated to separate uranium from thorium. Three different possible ways of fluorination are given. (GF)

**22339** METHOD FOR RECOVERY OF NUCLEAR FUEL. Baxter, W.; Naylor, A.; Wakerley, M. W. (to United Kingdom Atomic Energy Authority). German Patent 2,152,069. 27 Apr 1972. 5p. (In German).

A process for the recovery of nuclear fuel, encapulated in silicon carbide, is described in which fuel is treated with chlorine (at least 1,000°C) to remove the silicon carbide, and then the carbon is removed by oxidation. The process is applicable to the processing of nuclear fuel made of coated particles, which were either yielded during the preparation as waste or from irradiated fuel. Nuclear fuel compacts of coated uranium dioxide particles, which are dispersed in a silicon carbide matrix and in a silicon container or which are contained in a mixture of silicon and silicon carbide can also be processed by the method described. In the latter case, those coated compacts are crushed in a previous stage. (GF)

# ENGINEERING

## Energy Conversion

*Refer also to abstracts 22415, 23727, 24188, and 24198.*

**22340** (BNWL-SA-4259(Rev.)(DR)) PLOWSHARE STIMULATION OF GEOTHERMAL SYSTEMS. Stewart, D. H.; Burnham, J. (Battelle Pacific Northwest Labs., Richland, Wash.). [nd]. 9p. (CONF-720817-2). Dep. NTIS $3.00.

From Conference on nuclear power for tomarrow; Atlantic City, New Jersey, USA (22 Aug 1972).

The economics and feasibility of using nuclear explosions for recovering geothermal energy from natural and dry hot rock sources are reviewed. (TFD)

**22341** (JUL-883-TP) APPLIED MAGNETOHYDRODYNAMICS. Volume 10. MHD Experimental Installation ARGAS II: Description and Operating Experience. Bohn, T.; Grawatsch, K.; Komarek, P.; Lang, H.; Noack, G. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Technische Physik). Aug 1972. 85p. (In German). Dep. NTIS (U. S. Sales Only).

The new or changed components (such as experimental zone with nozzle, channel, diffuser, seed material cycle and superconducting magnets) of the enlarged ARGAS-I facility are described. Due to the high working temperature in connection with mechanical stress some problems in the high-temperature part were found, but the electric insulation and the thermodynamic behavior of the experimental zone fits the design well. The problem of continuous injection of Cs seed was solved, polluted Cs can be shunt to a purification cycle. A few improvements were made with respect to the recording of operational data. Good results were found for the controlled resistive loads of the 98 electrodes. The construction of the superconducting magnet and the cryogenic cycle is presented in some detail. The magnetic behavior was analyzed carefully because the magnet was designed for a maximum of 4T. (GF)

**22342** (MMM-2473-342) THERMOELECTRIC MATERIALS EVALUATION PROGRAM. Quarterly Technical Task Report, No. 39. Hampl, E. F. Jr. (Minnesota Mining and Mfg. Co., St. Paul. Electrical Products Group). 20 Oct 1972. Contract AT(29-2)-2473. 81p. Dep. NTIS $6.25.

The program for evaluating thermoelectric materials involves three tasks; N-type material development, P-type TPM-217 material characterization, and couple development. Work in progress in each of these tasks is described. (LCL)

**22343** POWER CYCLE TO ELIMINATE THERMAL POLLUTION. Potter, J. H. (Stevens Inst. of Tech., Hoboken, NJ). J. Eng. Ind.; 95: No. 1, 379-382(Feb 1973).

A cycle is proposed in which no condenser cooling water is required. Turbine backpressure is kept to conventional levels by condensing the steam during the evaporation of a refrigerant. Heat is rejected from the refrigerating loop in air coolers. Application of this concept to an 826 MW fossil-fueled power station shows the anticipated increases in heat rate and capital cost. (auth)

**22344** ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS. 12th Symposium, Argonne, Illinois, March 27–29, 1972. Petrick, M. (ed.). Argonne, IL; Argonne National Laboratory (1972). 367p. (CONF-720342–). Univ. of Mississippi $15.00.

From twelfth symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972).

Fifty-seven papers were presented at the conference. A separate abstract was prepared for each of 53 papers. Four papers were not received in time for publication in this volume. (LCL)

*For abstracts of individual papers see: 22345–22397.*

**22345** PERFORMANCE OF A NON-EQUILIBRIUM MHD GENERATOR WITH SLANTED ELECTRODE WALLS. Hsu, M. S. S.; Solbes, A.; Kerrebrock, J. L. (Massachusetts Inst. of Tech., Cambridge). pp I.1.1-I.1.7 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

An analysis of the electrical behavior of the plasma in the vicinity of a segmented electrode wall, slanted away from the magnetic field direction, is presented. The resulting theoretical performance of a generator, equipped with such electrode walls, is compared to that of a conventional flat wall generator. The experimental results obtained with a linear supersonic segmented non-equilibrium generator are presented. Comparison of the generator characteristics in the case of a 45° slanted electrode wall and of a nonslanted electrode wall indicate that the degree of electrode wall shorting is noticeably reduced at open circuit condition by using a 45° slant angle. At short circuit, axial shorting is observed for both configurations. This is explained, in the slanted wall case, by the convergence of the transverse current, at the apex of the V shaped electrodes, which creates a region of high conductivity and thus leads to an axial shorting. (auth)

**22346** ELECTRICAL INSULATION PROBLEMS IN DESIGN AND TESTS OF CLOSED CYCLE MHD GENERATORS. Gasparotto, M. (CNEN, Rome). pp I.2.1-I.2.8 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

An approach to the electrical insulation problems is attempted in order to provide a useful tool to evaluate, from this point of view, the design requirements and the consequences on the performance of an MHD duct. Several aspects are considered, such as calculation and design of the wall resistances, optimization of the channel transverse dimensions for maximum electrical insulation, and direct measurements of leakage resistances in an experimental channel. Finally, a theoretical model of the complex network of a multi-electrode channel is derived and a satisfactory qualitative comparison with experiments is reported. (auth)

**22347** EFFECTS OF ELECTRODE CONFIGURATION ON THE PERFORMANCE OF A FARADAY TYPE MHD GENERATOR. Houben, J. W. M. A.; Blom, J. H.; Rietjens, L. H. T. (Eindhoven Univ. of Tech., Netherlands). pp I.3.1-I.3.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The influence of the electrode configuration on the performance of a linear, nonequilibrium, Faraday type MHD generator was studied theoretically. Numerical, two-dimensional, calculations are carried out for a number of electrode configurations. In the mathematical model nonequilibrium ionization and relaxation effects in electron temperature and density are included. The velocity and temperature profiles are postulated. The Ar–Cs plasma conditions are taken from the Eindhoven shocktube experiment. The influence of electrode configuration with respect to voltage drops, axial leakages, emission problems and internal resistance is discussed. Comparison of flat electrodes in the generator wall with rod electrodes out of this wall results in a preference for the rod electrode configuration. (auth)

**22348** INFLUENCE OF IONIZATION TURBULENCE ON THE PERFORMANCE OF NONEQUILIBRIUM PLASMA MHD GENERATORS. Zampaglione, V. (CNEN, Rome). pp I.4.1-I.4.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

A correct evaluation of the effects of ionization turbulence on the performance of nonequilibrium plasma MHD generators is presented. Current calculations based on approximate turbulent plasma models are discussed and criticized. (auth)

**22349** PROGRESS IN ANALYTICAL MODELING OF MHD POWER GENERATORS. Demetriades, S. T.; Argyropoulos, G. S.; Maxwell, C. D. (STD Research Corp., Pasadena, CA). pp I.5.1-I.5.13 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

A realistic analytical method of modeling MHD power generators was developed, that has the ability to give accurate quantitative prediction of the performance and efficiency of a generator channel as a function of its size, and to dictate the choice of operating conditions and geometry that will optimize the efficiency and longevity of an MHD generator of a given size. The modeling was performed by numerical (digital) techniques. The local behavior at every point of an MHD channel was computed as a function of time by a unique solution, and the field distributions are then integrated to derive the overall performance characteristics. The effect of each one (or any combination) of the important physical mechanisms was investigated separately. This method was applied to existing real-life devices and produced results in excellent agreement with the experimental data. It can be used as a practical engineering tool for predicting the overall performance and optimizing the design parameters of both open-cycle and closed-cycle MHD power generators before they are built. (auth)

**22350** ELECTRODE EFFECTS AND GAS DYNAMIC CHARACTERISTICS OF A LARGE, NON-EQUILIBRIUM MHD GENERATOR WITH CESIUM-SEEDED NOBLE GASES. Zauderer, B.; Tate, E. (General Electric Co., King of Prussia, PA). pp I.6.1-I.6.10 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

An experimental study was performed to determine the factors limiting the power output of a linear, supersonic Faraday generator, having electrodes suspended in the gas flow. The test gases were cesium-seeded neon or argon at 2000 to 4000°K stagnation temperatures and 5 to 11 MW thermal power levels. It was observed that the electrode current varies directly with the cesium concentration for electrode current densities of the order of tens of amp/cm$^2$. The electrode current was nearly independent of electrode temperature and surface area. It was concluded that the electrode conduction was due to the cesium ion flux at the cathode. The gas dynamic characteristics of the generator as deduced from pressure and Mach number measurements were in fairly good agreement with the theory based on the one dimensional gas conservation equations. At electromagnetic interaction parameters in excess of 0.4, oblique shock waves were detected in the generator. The shock waves did not noticeably influence the power output. At 2150°K, 8.5% of the thermal power was converted to electric power at the external load. An equivalent amount of power was dissipated internally at the electrodes, primarily at the cathode. It is concluded that by using a larger MHD channel or by operating at higher gas pressures, cesium concentrations and magnetic field strengths, 20% heat to electric conversion ratios should be readily attainable. (auth)

**22351** EXPERIMENTS IN A FARADAY MHD GENERATOR WITH A SUPERSONIC SEEDED HELIUM FLOW WITHIN A RELAXATION REGION. Shioda, S. (Tokyo Inst. of Tech.); Osada, I.; Yamashita, I. pp I.7.1-I.7.10 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Experimental results of the performances of a nonequilibrium Faraday MHD generator within an ionization relaxation region are described. Methods for power generation with ionizing and recombining plasmas are proposed mainly with the purpose of generating power from seeded helium of low stagnant temperature (1500°K). Experimental results which were obtained with a double-diaphragm shock tube are: plasmas were in a nearly frozen state of ionization; generator performances could be well explained; and the power density was 7 ~ 15 MW/m$^3$ at magnetic field 11.3 KG and $\omega\tau$ 4 (stagnant pressure 4 atm), which corresponds to 60 ~ 130 MW/m$^3$ at magnetic field 100 KG and the same $\omega\tau$ (pressure 40 atm). Furthermore, some discussions and proposals concerning plasmas in a relaxation region are made. In a supersonic flow, the ionization relaxation length becomes long at electron temperature less than 2800°K. Plasma free from the electrothermal instability is possible when the plasma is ionizing. When electron temperature is low (~2000°K), recombining plasma may be recommended if the effective pre-ionization method is employed. (auth)

**22352** EMISSION CHARACTERISTICS OF CATHODES FOR MHD GENERATORS. Maslennikov, N. M. (All-Union Electrotechnical Inst., Moscow). pp I.8.1-I.8.4 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The results are presented of cathode voltage drop measurements in the flow of argon and argon-potassium plasma with non-activated and potassium-activated cathodes. The Schottky formula was applied to calculate the effective thickness of electrode sheath and the effective cathode electric field strength. (auth)

**22353** INVESTIGATION OF THE DISCHARGE STRUCTURE IN A RARE GAS ALKALI MHD GENERATOR. Brederlow, G.; Witte, K. J. (Max-Planck-Institut fuer Plasmaphysik, Garching, Ger.). pp I.9.1-I.9.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Investigations of the discharge in the duct of a rare gas alkali MHD generator by means of image converter photographs and probe measurements are described. The aim of these experiments was to determine the causes of the current concentration that occurs in rare gas alkali MHD generators and leads to a striated discharge structure. Similar current concentrations have been found theoretically under equivalent conditions. In these theoretical investigations the current and potential distributions in an ideal rare gas alkali generator are calculated. It was found that the disturbances caused by the discontinuities in the boundary conditions (segmentation) propagate into the plasma along the current and field lines if the Hall parameter exceeds a critical value. Accordingly, a striated discharge structure forms in the generator duct in accordance with the electrode geometry. (RCK)

**22354** CURRENT AND POTENTIAL DISTRIBUTIONS IN MHD ENTRANCE FLOWS. Blom, J. H.; Sielhorst, C. J.; Houben, J. W. M. A.; Rietjens, L. H. T. (Eindhoven Univ. of Tech., Netherlands). pp I.10.1-I.10.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The behavior of the current pattern in preionizers has been computed for Hall parameters below and above the critical value. The time-dependent and stationary two-dimensional calculations make use of an integration of continuity and energy equation along characteristics. In the mathematical model nonequilibrium ionization and relaxation effects in electron temperature and density are included. The Ar-Cs plasma conditions are taken from the Eindhoven shocktube experiment. Stationary solutions for $\beta < 2$, and time-dependent solutions for $\beta > 2$ are presented. The time-dependent solutions do not show any sign of physical nor numerical instabilities. (auth)

**22355** THEORETICAL AND EXPERIMENTAL STUDIES OF MAGNETOHYDRODYNAMIC POWER GENERATOR WITH CHAR. Wu, Y. C. L.; Dicks, J. B. Jr.; Crawford, L. W.; Muehlhauser, J. W.; Scott, M. A.; Sood, N. (Univ. of Tennessee, Tullahoma). pp II.1.1-II.1.14 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The use of char combustion gas as a working fluid in the MHD generator was investigated theoretically and experimentally. The study showed that working gases for ideal MHD generators contain high amounts of carbon and small amounts of hydrogen, and that gas mixing and smooth combustion can be obtained with the feeding of pulverized fuel. The experiments confirmed the superiority of char combustion gas as compared to that of all other fuels feasible for central power MHD use. It is concluded that the use of char as a fuel in the MHD process can decrease the cost of some components of the MHD system by about 40% and may make base load plants possible at an earlier date than if coal is used directly. (LCL)

**22356** COMPARATIVE ENGINEERING ASPECTS OF DISK AND LINEAR MHD GENERATORS APPLIED TO OPEN CYCLE POWER GENERATION. Klepeis, J. E.; Louis, J. F. (Avco-Everett Research Lab., Everett, MA). pp II.2.1-II.2.2 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Although the basic physics of various MHD generator geometries is the same, generator performance and engineering complexity differ by the nature of the boundary conditions. Disk and linear generators are compared as regards scaling laws, performance, and general engineering design. (LCL)

**22357** FURTHER ANALYTICAL INVESTIGATIONS OF MHD GENERATOR PERFORMANCE. Sonju, O. K.; Teno, J. (Avco-Everett Research Lab., Everett, MA). pp II.3.1-II.3.8 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

An analytical method for investigating MHD generator performance is proposed. The method gives attention to: end effects, as related to power extraction techniques and as related to avoiding channel arc-overs with associated channel deterioration; stability, as it relates to maintaining a steady flow and a steady and optimum value of the power output; and channel behavior under transient loading conditions, particularly, as it relates to the capability of the generator to supply a given power output under changing load conditions without stalling and requiring restart. Comments applicable to the analyses presented include: the present three-dimensional analysis of end effects is an advance over the past two-dimensional versions in that presently, only boundary conditions where the electric potential is known, are considered; the stability theory rests on a linearized small signal perturbation theory. The limits on the applicability of this theory have not yet been established, and the transient analysis is presently based on the generator impedance established in the stability analysis. The accuracy of the transient analysis is governed by the limitations in the linearized stability analysis. (LCL)

**22358** MHD ENERGY CONVERSION USING DETONATION CONDITIONS. Yimerin, D. G.; Mironov, E. A.; Popov, V. A.; Valaiev, A. A.; Bogachev, V. N. (Power Engineering Inst., Moscow). pp II.4.1-II.4.7 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The gas-fuel detonation MHD generator of a laboratory type was constructed and tested under detonation conditions. Oxygen was taken as an oxidant, but it is believed that no difficulties will arise when changing to air. For the final checking the effectiveness of detonation MHD generators it is necessary to carry out a series of investigations and calculations. The utilization of the detonation MHD generator looks promising in terms of: the capability of the installation due to its construction features to operate for a long time with alternate high temperature of the combustion products in the pulse and low (room) temperature of the gas mixture; the absence of compressors for fuel and oxidant; the absence of the high-temperature heat-exchanger; direct generation of the alternating current; and its inertialess starting. It is assumed that these features of the installation may be attractive when constructing the peak and emergency power source. At present the effectiveness of such a generator involving the speed-up nozzle as well as the technical-economical efficiency is being investigated. (LCL)

**22359** HOT CERAMIC ELECTRODES FOR OPEN-CYCLE MHD POWER GENERATION. Meadowcroft, D. B.; Meier, P. G.; Warren, A. C. (Central Electricity Research Labs., Leatherhead, Eng.). pp II.5.1-II.5.3 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Three materials were tested as MHD electrodes under generating conditions. The materials were castable calcia-stabilized zirconia, 50 mol % ceria-zirconia, and strontium-doped lanthanum chromite. After 106 min of running time the ceria-zirconia electrodes were badly eroded; the calcia-stabilized zirconia had shown itself to be useful electrode material, and the lanthanum chromite electrodes were scarcely damaged. It is concluded that strontium-doped lanthanum chromite should be given much further attention as a hot MHD electrode with a front face temperature up to from 1600 to 1700°C. (auth)

**22360** THREE-DIMENSIONAL CURRENT DISTRIBUTIONS AND ELECTRODE CONFIGURATION EFFECTS IN DIAGONAL WALL GENERATORS. Koester, J. K.; Nicholson, M. K. (Univ. of Tennessee, Tullahoma). pp II.6.1-II.6.11 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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The configuration effects on performance of insulating versus conducting sidewalls for diagonal wall generators was studied experimentally and analytically. For cold wall generators, the conducting sidewall is found superior in agreement with the transverse distribution model which includes the voltage drop in the boundary conditions. Three-dimensional current distributions are measured and large non-uniformities are observed at high values of Hall field. The anode voltage drop is found to depend on boundary layer thickness, the anode-sidewall corner, and the surface coating, as well as current density. (auth)

**22361** TWO MEGAWATT HIGH-PERFORMANCE COMBUSTION-DRIVEN MHD GENERATOR EXPERIMENT. Sonju, O. K.; Teno, J. (Avco Everett Research Lab., Everett, MA). pp II.7.1-II.7.4 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The Viking I Program of analytical and experimental studies of compact, high-performance, high-interaction combustion-driven MHD generators is described. Generators using conventional hydrocarbon fuels were considered. The main purpose of the program is to further improve the specific power output of MHD generators. Other facets of MHD generator operation and performance such as rapid starting, multi-pulse operation, and transient behavior under changing load conditions will also be investigated. A high-performance generator presently under construction is predicted to be capable of a specific power output of about 0.8 MJ/kg under optimized conditions. (LCL)

**22362** HEAT TRANSFER OF COMBUSTION GAS PLASMA IN ELECTRIC FIELDS. Mori, Y.; Ohtake, K.; Ogasawara, K. (Tokyo Inst. of Tech.). pp II.8.1-II.8.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

One of the most serious problems in the development of practical open-cycle MHD generators is the life of the electrodes. A detailed analysis of the heat transfer of plasma to a relatively cold wall in a wide current density region is required as one of the essential investigations of electrode life and also for an understanding of phenomena near a cold electrode in an electric field. The theoretical and experimental study is described of heat transfer from a kerosene-fired and KOH-seeded combustion gas plasma to a cold metal tube inserted in it, when various electrical potentials are applied between them. Below a relatively small current density, the flow and temperature fields are analyzed in consideration of Joule heating and a model for a frozen electron temperature is proposed in a low gas temperature region in the vicinity of the cold surface. For the high current region, heat flux due to the work function and the bombardment of electron to the surface are taken into account to explain the experimental results. (auth)

**22363** ONE-HALF MEGAWATT LONG DURATION GENERATOR MODELING EXPERIMENT. Petty, S. W.; Rosa, R. J.; Sonju, O. K.; Jackson, W. D. (Avco-Everett Research Lab., Everett, MA). pp II.9.1-II.9.3 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The Mark VI MHD generator is an experiment designed primarily to demonstrate channel life and reliability under realistic and extended operational conditions and is part of an effort to model and test MHD design features on a scale sufficient to simulate as closely as possible the conditions encountered in a full-scale commercial plant. The requirements for such a long-term test facility are discussed. The arrangement and equipment of the test facility are described. (LCL)

**22364** INVESTIGATION OF HEAT FLUXES AND EROSION OF COOLED ELECTRODES IN A CONDUCTING GAS FLOW. Yimerin, D. G.; Motulevich, V. P.; Chekalin, E. K. (Power Engineering Inst., Moscow). pp II.10.1-II.10.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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The system of cooled metal electrodes of MHD channel should be reliable and effective so as to secure economically profitable operation of the open-cycle MHD generator for a long period of time (about 10,000 hr). The basic disadvantages of the cooled electrode system are the heat losses in a channel, formation of the cooled boundary layers near the electrode surface and destruction of the electrodes due to erosion. The formation of the thick temperature boundary layers, if the MHD channel sizes are small, results in a relatively large voltage drop in these layers and an increase in the internal resistance of the MHD generator. The lifetime for the electrodes is determined by the erosion due to the cathode spots. As the cathode spots occur, the heat fluxes also increase. If large currents pass through the cooled metal electrodes, then the non-stationary cathode spots inevitably arise, followed by the field emission of electrons. If the electrodes are insufficiently cooled, then the thermionic-field emission or stationary thermionic emission spots are also formed which cause a dangerous increase in the erosion and heat fluxes to the electrodes. Experimental results are described for the heat fluxes and erosion of the electrodes associated with the operation of the non-stationary cathode spots. The erosive intensities measured experimentally are compared to those predicted by calculation. (auth)

**22365** EXPERIENCES WITH THE OPEN CYCLE MHD FACILITY VEGAS. Bohn, T.; Grawatsch, K.; Hsu, M. S. S.; Kolb, G.; Kupschus, P.; Kuehne, W. D.; Lang, H.; Noack, G.; Schabel. P. (Kernforschungsanlage, Juelich, Ger.). pp II.11.1-II.11.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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After a short description of the VEGAS facility, the essential experiences in the field of channel material technology are reported. Several kinds of materials for electrodes and insulators were tested. MgO for the insulators and cobalt-based alloys for the electrodes proved to be especially suitable. It should be noted that the channel is developed for longtime operation with electrode temperatures in the 1200°C range and insulator temperatures from 1700 to 2400°C. Particular attention has been paid to the thermodynamic behavior of the entire system. Heat losses and temperatures at different channel locations were determined. With respect to the electric behavior of the channel, it was demonstrated that the power is different by an order of magnitude within some 100°C wall temperature. This effect is related to electrode drops and conductivity decrease in the boundary layer. The results are compatible with theoretical considerations. In view of the importance of exhaust gas problems with respect to the development of combustion MHD generators, a gas analysis equipment was installed to measure the toxic components of the exhaust gas. The CO concentrations measured are reported. (auth)

**22366** INFLUENCE OF VARIOUS LOSS MECHANISMS ON THE FLOW PARAMETERS OF A SEEDED COMBUSTION PLASMA. Zankl, G.; Raeder, J.; Buende, R. (Max-Planck-Institut fuer Plasmaphysik, Garching, Ger.). pp III.1.1-III.1.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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Investigations are reported of the flow of a seeded combustion plasma (kerosene + potassium octoate + liquid oxygen) through a combustion chamber ($p_c = 14$ bar), Laval nozzle, and channel. The Mach number at the channel entrance was 1.5. Calculations were performed for the combustion and for the flow through the combustion chamber, nozzle, and channel. The theory starts from the idealized conditions for combustion and gas flow and then takes into account step by step the following deviations from ideal behavior: incomplete combustion; turbulent heat losses to the walls; radiation losses; and turbulent wall friction. The influence of, in particular, chemical equilibrium, frozen chemical reactions, the wall temperature, and increased wall friction was studied numerically. Measurements of temperature, pressure, heat flux density, electrical conductivity, and velocity along the channel were made. Comparison of the measured and calculated distributions of temperature, pressure, heat flux density, electrical conductivity, and velocity yielded a reasonable agreement and emphasized the importance of taking into account the above mentioned loss mechanisms. (auth)

**22367** NON-LINEAR ANALYSIS OF MHD PLASMA TURBULENCE. Wisnivesky, D. (Observatorio Nacional de Fisica Cosmica, San Miguel, Argentina). pp III.2.1-III.2.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

A full nonlinear theory to study the turbulent regime of a partially ionized nonequilibrium plasma was developed using the Random Phase Approximation. A simple plasma model was chosen as a framework to illustrate the theory. The turbulent regime was assumed to be two-dimensional and stationary. Keeping all orders in the electron temperature fluctuations, a pair of equations for the average and fluctuation electron temperature was derived. The solution indicates that $\beta_{eff}$ increases linearly with $\beta$, with a small slope and $\sigma_{eff}$ saturates at a small fraction of $\sigma_0$. When $\beta$ increases, the turbulent spectrum widens. The turbulently dissipated energy raises the mean ionization level and forces the density fluctuation to decrease. In the turbulent regime the Hall parameter plays a role similar to the current density $j_0$. (auth)

**22368** COMBUSTION OF COAL AND CHAR FOR MHD POWER GENERATION. Crawford, L. W.; Dicks, J. B. Jr.; Crowl, R. W.; Muehlhauser, J. W. (Univ. of Tennessee, Tullahoma). pp III.3.1-III.3.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Preliminary results are presented of an experimental and theoretical study of combustion of pulverized coal and char for application to MHD power generation. The studies were carried out in a combustion chamber of 0.010 s retention time, using parallel axial injection of the reactants. Variables investigated included seed compound and method of injection, fuel particle size, and technique of fuel injection. The major experimental outputs include combustion chamber pressure and electrical conductivity of the combustion gases. Chemical analysis of exhaust gases was performed for a limited number of tests. In all cases, combustion efficiency was rather low because of the small retention time for combustion. Results indicated that for fuel and potassium sulfate particles passing a 200 mesh screen (74 μ dia) combustion was efficient enough to indicate that a combustion chamber only a few times larger should allow combustion and seed evaporation to proceed at high efficiencies. Theoretical calculations indicate that particles less than 325 mesh (44 μ) should burn even in the small combustion chamber used. (auth)

**22369** LASER DOPPLER VELOCIMETER FOR MHD BOUNDARY LAYER STUDIES. Self, S. A. (Stanford Univ., CA). pp III.4.1-III.4.4 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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An instrument was designed and constructed for measuring the average flow velocity and the amplitude of turbulent velocity fluctuations in an MHD channel flow, making use of the Doppler frequency shift of laser light scattered from macroscopic particles added to the flow. The spatial resolution is sufficient for the determination of the velocity profile in the boundary layer adjacent to an electrode. The velocimeter has performed satisfactorily on model, cold flows. Preliminary tests on the Stanford combustion MHD facility indicate some improvements are required before the full potential of the technique can be realized. (auth)

**22370** ELECTRICAL BREAKDOWN OF ELECTRODE BOUNDARY LAYERS. Messerle, H. K.; Ho, N. L.; Heffernan, L. P. (Univ. of Sydney). pp III.5.1-III.5.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The mechanism of electrical breakdown in electrode boundary layers was studied allowing for steep temperature gradients at the surface. The physical nature of the layers suggests two alternative causes, i.e., thermal collapse due to joule heating or electrostatic breakdown at the cathode surface and two corresponding breakdown criteria are established. It is shown that field-effect breakdown is the likely dominant cause and the possibility of thermal breakdown is increased with higher ionic mobility of the seed, lower thermal conductivity of the carrier gas, small temperature drop near the electrode, and thicker boundary layers. Breakdown and arc spot formation are necessary in most practical situations, in order to enhance the current flow through an MHD generator duct, although this leads to increased erosion and streamer formation. (auth)

**22371** CONTRIBUTION TO THE DETERMINATION OF THE ELECTRIC CONDUCTIVITY OF COMBUSTION PLASMA FROM DIFFERENT TYPES OF RUHR COAL. Wissel, K.; Schilling, H. D.; Niesert, E.; Peters, W. (Bergbau-Forschung GmbH, Essen). pp III.6.1-III.6.8 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The electric conductivity of combustion plasma from a total of ten different Ruhr coals was determined experimentally at atmospheric pressure for a temperature range of from 2300 to 2850°K and seed quantities up to 116 g $K_2CO_3$/kg coal. The essential factors influencing the electric conductivity are the plasma temperature and the seeding as test parameters and the volatile matter contents of the test coals. The dependence of the electric conductivity on temperature and on seeding as individual factors of influence as well as combined variants can be described relatively well by functions derived from theory. The electric conductivity of the combustion plasma increases with increasing rank of the coals. As for the ash contents, a conductivity maximum can be found at about 4% (by weight) ash of the coals. The effect of the $K_2O$ bonded in the coal was not seen, but high iron content seemed to increase the conductivity. A comparison of the measured and the calculated conductivities showed good agreement for the unseeded case. When adding seed material, some of the calculated values become much smaller. (auth)

**22372** SELF CONSISTENT CALCULATION OF THE GASDYNAMIC AND ELECTRICAL PROPERTIES OF A TWO-DIMENSIONAL MHD FLOW. Fritzer, P. (Univ., Innsbruck); Lengyel, L. L.; Witte, K. J. pp III.7.1-III.7.8 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The two-dimensional laminar compressible flow, in the plane perpendicular to the magnetic field lines, of an electrical conducting gas in thermodynamic equilibrium was investigated at low values of the interaction parameter in a Faraday-type MHD generator with finitely segmented electrodes. The coupling between the gasdynamics and the magnetic field via the Lorentz force in the momentum equation and the ohmic heating in the energy equation was taken into account. The transport properties such as electrical and thermal conductivity and viscosity were treated as functions of the gas temperature and density. For the numerical integration of the coupled, non-linear partial differential equations a modified form of the Fluid-in-Cell-Method was used. Its numerical stability was satisfactory in all examples considered. (RCK)

**22373** NONEQUILIBRIUM GASDYNAMIC AND IONIZATION PHENOMENA IN A GAS-PARTICLE PLASMA. Shanklin, R. V. III; Crawford, L. W. (Univ. of Tennessee, Tullahoma). pp III.8.1-III.8.7 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The theoretical effects of nonequilibrium phenomena on the electric conductivity of combustion gases generated by an aluminized fuel, seeded with potassium nitrate, are considered. The lag in velocity and temperature, between particles and gas during rapid expansion to supersonic flow and subsequent flow in a slowly diverging channel, appears to be the cause of unusual behavior of the conductivity of the gases. This unusual behavior consists of an increase in conductivity with expansion in the channel. The effect of nonequilibrium ionization due to differences in particle and gas temperature is negligible for the system under consideration. (auth)

**22374** ANALYSIS OF LIQUID–METAL MHD POWER CYCLES FOR CENTRAL STATION POWER GENERATION. Amend, W. E. (Argonne National Lab., IL); Petrick, M.; Cutting, J. C. pp IV.1.1-IV.1.13 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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Two-phase liquid-metal power cycles have the potential to efficiently generate electrical power from heat sources which deliver energy in the range from 1000 to 2000°F. They appear to be compatible with a variety of heat sources, both nuclear and nonnuclear, currently under development. As examples, the LMFBR is projected to provide thermal energy in the range from 1000 to 1400°F while fusion reactor would be capable of supplying energy to the working substance up to 2000°F. The fluidized-bed combustor is a fossil-fuel heat source being developed to provide "clean" energy from high-sulfur-content coal at temperatures in the range from 1400 to 1600°F. Finally, the MHD open-cycle-plasma generator will have the capability of rejecting its waste heat to a liquid metal in the range of from 1600 to 2000°F to form a high-efficiency, all-MHD binary cycle. A study of the suitability of employing the two-phase Faraday generator in the production of large-scale electrical power is described. This work, which has been carried out over the past two years, is currently drawing to a close. The important findings of this research are summarized. (RCK)

**22375** RECENT EXPERIMENTAL RESULTS FROM A ONE-WAVELENGTH MHD INDUCTION GENERATOR. Pierson, E. S. (Univ. of Illinois, Chicago). pp IV.2.1-IV.2.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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An experimental one-wavelength-long MHD induction generator was operated successfully on a NaK flow system with a variety of excitation conditions, including tests both with and without compensating poles. The experimental generator is described briefly. A Fourier series method of calculating the magnetic flux density is extended to include power calculations. Initial results from over 200 data points are summarized, with detailed analysis to follow. (auth)

**22376** NUMERICAL ANALYSIS METHOD FOR LINEAR INDUCTION MACHINES. Elliott, D. G. (Jet Propulsion Lab., Pasadena, CA). pp IV.3.1-IV.3.9 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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A numerical analysis method was developed for linear induction machines such as liquid metal MHD pumps and generators and linear motors. Arbitrary phase currents or voltages can be specified and the moving conductor can have arbitrary velocity and conductivity variations from point to point. The moving conductor is divided into a mesh and coefficients are calculated for the voltage induced at each mesh point by unit current at every other mesh point. Combining the coefficients with the mesh resistances yields a set of simultaneous equations which are solved for the unknown currents. (auth)

**22377** EXPERIMENTAL INVESTIGATION OF A CONSTANT VELOCITY, TWO-PHASE, DC, LIQUID–METAL MHD GENERATOR. Pittenger, L. (Argonne National Lab., IL); Cole, R.; Pierson, E. S. pp IV.4.1-IV.4.2 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Theoretical analyses have indicated that high-cycle efficiencies may be attained in MHD power plants utilizing a two-component, two-phase mixture of an alkali metal and an inert gas as the working medium. A basic requirement for such systems is an efficient two-phase generator. Therefore, a series of experiments aimed at developing such a generator were carried out. An experiment now in progress, designed to further development of two-phase, dc MHD machines is described. (auth)

**22378** ELECTROTHERMAL INSTABILITY WITH EFFECTS OF ELECTRON THERMAL CONDUCTION AND WALL BOUNDARIES. Shioda, S. (Tokyo Inst. of Tech.); Huruya, I. pp V.1.1-V.1.7 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Linear stability analysis of electrothermal instability was carried out including effects of electron thermal conduction and wall boundaries (and also including radiation, convection, compressional heating and finite rate of ionization and recombination). Two cases were treated: current was parallel to the walls and current was perpendicular to walls. Then the most unstable perturbation could be determined uniquely under the influence of wall boundaries and electron thermal conduction. In both cases the size of the most unstable perturbation was almost the channel depth which is in good agreement with experimental results by Riedmueller in the case of current parallel to walls. When the channel depth is small, critical Hall parameter becomes high due to effects of electron thermal conduction and radiation. Phase velocity is almost independent of wave number in the case of current parallel to walls, but in the case of current perpendicular to walls it decreases as wave number increases. Phase shift between electron temperature and electron number density increases linearly with increasing wave number in the case of current parallel to walls but in another case phase shift weakly depends on wave number. (auth)

**22379** IONIZATION INSTABILITIES AND DISCHARGE CHARACTERISTICS OF AN MHD LASER. Oliver, D. A.; Solbes, A.; Kerrebrock, J. L.; Lowenstein, A.; Grove, R. (Massachusetts Inst. of Tech., Cambridge). pp V.2.1-V.2.13 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

An experimental and theoretical study of the behavior of an MHD laser discharge is presented with particular emphasis on the interaction of the ionization instabilities and the lasing radiation field. The inclusion of a $CO_2$ molecular lasing medium in a nonequilibrium helium-cesium MHD discharge leads to the development of ionization instabilities and an effective plasma conductivity and Hall parameter which are indistinguishable from those for helium-cesium plasmas. Dissociation of $CO_2$ was observed in these discharges with dissociation times of the order of the instability growth time. Without a magnetic field, but with lasing oscillation of the discharge, $CO_2$ dissociation was again observed. A kinetic-electrical-radiative theory is presented which is used to predict the behavior of the experimental discharge and of the growth and evolution of ionization instabilities in a lasing plasma. It is found that the instabilities grow faster in the presence of the lasing radiation field than without lasing radiation. (auth)

**22380** STABILITY OF THE NONEQUILIBRIUM MHD PLASMA IN THE REGIME OF FULLY IONIZED SEED. Nakamura, T. (Max-Planck-Institut fuer Plasmaphysik, Garching, Ger.). pp V.3.1-V.3.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

A detailed experimental study of the properties and the stability of the cesium seeded argon plasma in the regime of fully ionized seed is presented. It is shown that the regime of fully ionized seed can be moved to a desired current density and its corresponding level of conductivity by controlling the seed fraction. In the stable regime, Hall parameter reached the value of 6.6 with conductivity value of 0.5 mho/cm at the magnetic field strength of 23 kG. Measurements of electron temperature and electron density confirmed that it is indeed the ionization of the noble gas that limits the stability of the plasma. The experimental data agree satisfactorily with the previously derived expression for the critical Hall parameter. Experimental conductivity is expressed in terms of the basic plasma parameters. Based on these experimental evidences it was concluded that it may not be difficult to attain the stable state of the plasma in actual MHD generators. (auth)

**22381** MAGNETO-ACOUSTIC INSTABILITIES IN THEIR RELATION TO MAGNETIC INTERACTION. Veefkind, A. (Stanford Univ., CA). pp V.4.1-V.4.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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In combustion MHD generators operating with magnetic interaction parameters larger than one, magneto-acoustic instabilities may cause degradation of performance. The instabilities should be considered as subjected to the boundary conditions imposed by the load circuit. A linear analysis including these boundary conditions is presented. Calculations are given concerning the influence of current reduction and of larger magnetic interaction on the growth. (auth)

**22382** FEEDBACK CONTROL OF IONIZATION INSTABILITY. Sen, A. K. (Technical Univ., Eindhoven, Netherlands). pp V.5.1-V.5.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

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A scheme of stabilization of ionization instability by linear feedback is presented. The electron density perturbation of an ionization wave is sensed by a biased single probe, appropriately processed by an active electronic network and fed back into the nonequilibrium plasma. The feedback signals in form of currents are injected into the plasma via pairs of small control electrodes. The necessary structure of the electronic network is indicated and it is shown that for reasonable parameters of this network, stabilization can be achieved. (auth)

**22383** INSTABILITY OF NONEQUILIBRIUM PLASMA INCLUDING INDUCED FLUCTUATING MAGNETIC FIELD. Coakley, J. F.; Porter, R. W. (Illinois Inst. of Tech., Chicago). pp V.6.1-V.6.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

It is shown that the long-wave instabilities associated with large-scale closed-cycle MHD generators are influenced by the fluctuating magnetic field induced by the fluctuating electric current. The analysis is based on plane waves and the two-fluid model for electrons and heavy particles. Included are electron-neutral and electron-ion collisions, differential mean particle motion, temperature nonequilibrium, thermal diffusion and radiation. Chemical nonequilibrium is neglected. Five wave modes are identified including the potentially unstable electrothermal and magnetoacoustic (pair) modes. The generally stable modes include the thermal mode and the electromagnetic mode, nor previously noted in the present application. It is found that the fluctuating magnetic field is important typically for wavelengths longer than 10 cm. The dominant electrothermal instability is affected in two ways. First, growth rates are reduced increasingly at longer wavelengths. Second, the phase velocity can be negative with respect to the mean electric current at long wavelengths. Radiation damping is also found to be of importance in determining the critical Hall parameter for wavelengths as long as 1 meter. Comparisons with previous theory and experiments are included in order to determine the differences between long and short wavelengths. Approximate simple dispersion relations are also discussed. (auth)

**22384** EFFECTS OF CHANNEL SIZE ON THE IONIZATION INSTABILITY IN MHD GENERATORS. Evans, R. M.; Kruger, C. H. (Stanford Univ., CA). pp V.7.1-V.7.11 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

An experimental and theoretical study of the ionization instability in nonequilibrium, continuous-electrode MHD generators is presented. Experiments were conducted in a continuous-electrode MHD generator with externally augmented electric fields to investigate the influence of electrode separation on the development and effects of the ionization instability. A linear perturbation analysis of the governing equations was developed to predict the dependence of the critical Hall parameter for growth of the instability on the electrode separation, current density, and magnetic field. The experiment and theory were in general agreement and showed that the wavelength decreased with increasing magnetic field, with increasing current density, or with decreasing electrode separation. The critical Hall parameter was found to decrease with increasing electrode separation and to vary with the current density. From the experiments it was found that the effective Hall parameter decreased with increasing magnetic field or increasing electrode separation. The effective scalar conductivity showed no appreciable change for the three electrode separations. (auth)

**22385** IONIZATION INSTABILITY IN THE NONLINEAR REGIME. Mitchner, M.; Zampaglione, V. (CNEN, Frascati, Italy). pp V.8.1-V.8.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

A nonlinear model of the ionization instability was constructed on the assumption that the discharge structure consists of alternating layers of high and low electrical conductivity, the steady-state electron energy equation being satisfied in each layer. For specified layer thicknesses, the model predicts for each value of the Hall parameter only a certain range of allowable values for the angle between the layers and the average current density. Some of the features of the discharge structure appear to be in qualitative accord with experiments. It is shown that two classes of discharge structure are consistent with the observed saturation in the value of the effective Hall parameter for large magnetic fields. The allowed values of the angle between the layers and the average current are either larger or smaller than the value predicted by the linearized instability theory. The calculations indicate that experimentally observed "streamers" and "striations" may both be manifestations of the ionization instability in the nonlinear regime. (auth)

**22386** TWO-DIMENSIONAL CALCULATIONS OF IONIZATIONAL FLUCTUATIONS IN A HELIUM-CESIUM GAS AT REST. Kolb, G. (Kernforschungsanlage, Juelich, Ger.). pp V.9.1-V.9.7 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The results presented are the continuation of numerical computations to higher Hall parameters. According to experiments made by Bohn, at a time $t = 0$ an external voltage U, together with an external magnetic induction B, both constant in time, were applied to a helium-cesium plasma ($Tg = 2100°K$, $N_{He} = 10^{24}\ m^{-3}$, $N_{Cs} = 10^{22}\ m^{-3}$) contained within a prism of two rectangular electrodes and two insulator walls. The temporal behavior of the current and the distributions of the potential, the electron temperature, $T_e$, and the electron density, $n_e$, were calculated in a two-dimensional time-dependent numerical treatment (electrode distance $L = 3$ mm, applied voltage $U \sim 0.4 + 0.45$ volt, magnetic induction B up to 0.7 Tesla, corresponding to an Hall parameter $\beta(Tg) \sim 4.57$ at the gas temperature Tg). Three-dimensional plots show the development and disappearance of ionizational fluctuations in a restricted part of the discharge space in the vicinity of one of the electrode corners. (auth)

**22387** DISPERSIVE WAVES IN A SEEDED MHD GENERATOR. Harstad, K. G. (Jet Propulsion Lab., Pasadena, CA). pp V.10.1-V.10.4 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The equations giving the response of a slightly ionized plasma with monatomic components to sinusoidal perturbations were formulated. Included in the model equations were the electron Hall effect, electron thermal diffusion, radiation, and electron-atom rate processes. Plasma conditions were limited to those where viscous effects, the induced magnetic field, ion slip, and atom-atom inelastic processes can be neglected. Presented are results of numerical calculations for MHD generators with a working fluid of potassium seeded argon. (auth)

**22388** TWO-POINT CORRELATION DESCRIPTION OF THE PROPERTIES OF A PLASMA SUBJECTED TO THE ELECTROTHERMAL INSTABILITY. Kim, C. S.; Townsend, S. J. (Univ. of Toronto). pp V.11.1-V.11.7 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Calculations were made of the magnitude of fluctuations of electron number density and of temperature in an MHD working plasma which is subject to the electrothermal instability by means of introducing two-point correlation functions. The "collective" plasma transport properties, namely, effective electrical conductivity, and Hall parameter, as well as radiation and heat transfer are considered in the derivation. The formalism of the two-point correlation functions is described briefly on the basis of a steady local equilibrium assumption and the linearized electron rate and energy equations. Within this formalism one can study the time behavior of the correlation functions with appropriate initial values. It is argued that there may exist stable, steady correlations for wave numbers of the disturbance within a certain range of the present study. The results describe not only the non-stationary buildup from linear instability to saturation but also describe the turbulence that eventually develops after the evolution of this instability. (auth)

**22389** COMBUSTION MHD GENERATOR AS A RESERVE PLANT IN ELECTRICITY SUPPLY SYSTEMS. Buende, R. (Max-Planck-Institut fuer Plasmaphysik, Garching, Ger.); Muntenbruch, H.; Helm, S. pp VI.1.1–VI.1.11 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

The possibilities of applying kerosene-oxygen fired MHD plants for reserve power production were investigated. The costs of power generation by a plant that can reach its full load only 0.3 to 0.5 s after being started were determined. When this plant is only operated up to about 100 h/y, the total power generation costs per y are lower than those incurred by other reserve power supply methods. This MHD plant is thus suited to short-period reserve power production required to prevent breakdown of the grid in the event of sudden shutdown of a unit. At present some utilities (whose maximum power unit size is relatively low compared with their total installed power) provide the necessary short-period reserve by running the units a few per cent below full load, while other utilities or industrial power plants whose maximum power unit size is relatively high compared with the total installed power buy short-time reserve power from bigger utilities. It is shown that the costs for providing short-time reserve power in both cases can be greatly reduced by using combustion MHD generators. (auth)

**22390** PRODUCTION OF CLEAN WORKING FLUID FOR COAL BURNING, OPEN-CYCLE MHD POWER GENERATION. Lacey, J. J.; Demeter, J. J.; Bienstock, D. (Pittsburgh Energy Research Center). pp VI.2.1-VI.2.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

A preliminary process design is presented for a three-stage high-temperature coal combustion pilot plant capable of producing a hot, relatively ash-free combustion gas suitable for open-cycle MHD power generation. The system will operate at 8.0 atmospheres and consists of a 1st stage vertical cyclone gasifier, a 2nd stage fluid bed CO$_2$ reformer, and a 3rd stage vertical cyclone combustor. Pulverized coal is fed to the 1st and 2nd stages, and preheated air to the 1st and 3rd stages. Gasifier temperature is controlled with recycle flue gas which indirectly minimizes overall system heat losses. The design was based on a typical Pittsburgh seam of high-voltage bituminous coal and indicated that the product gases would leave the combustion system at 4300°F, retaining less than 10% of the input coal ash. (auth)

**22391** APPRAISAL OF COAL-GASIFICATION SCHEMES FOR MHD POWER GENERATION. Bergman, P. D.; Plants, K. D.; Demeter, J. J.; Bienstock, D. (Pittsburgh Energy Research Center). pp VI.3.1-VI.3.7 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

To assess the efficacy and economics of producing power from coal four open-cycle MHD processing schemes were selected for study. Each involved a different mode of coal combustion and level of gas cleanliness. The options considered were: (1) coal burned in a slagging combustor; (2) suspension gasification with slag removal prior to combustion; (3) parallel cyclone combustors operating fuel rich and with excess air; and (4) gasification by the hot exhaust gases from the MHD duct with ash removed prior to combustion. Option 1 has the highest ash content in the combustion plasma and as a result would have the greatest operational difficulties associated with it. Options 2 and 4 have the cleanest MHD combustion plasmas. The power generating cost of Option 4, 11.7 mills/kWh, is the highest, with Option 1, at 9.0 mills/kWh the lowest. These costs may be compared with conventional power cost of 9.9 mills/kWh for the late seventies. Option 2 has the most favorable combination of operating characteristics and power cost. It was concluded that a clean, high-temperature working fluid can probably be produced from coal without leading to depressed system efficiencies and exorbitant capital costs. (auth)

**22392** CONTROL TECHNIQUES FOR NITROGEN OXIDES IN MHD POWER PLANTS. Hals, F. A.; Lewis, P. F. (Avco-Everett Research Lab., Everett, MA). pp VI.5.1-VI.5.10 of Engineering Aspects of Magnetohydrodynamics. Petrick M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Air pollution control of nitrogen oxides is a very important consideration for any combustion process and particular attention has been directed to this for the high-temperature MHD combustion process. Detailed experimental and analytic studies of a control technique for direct reduction of nitrogen oxides in MHD combustion gases are described. It is based upon the use of two-stage combustion or afterburning in which case the combustion in the MHD burner occurs slightly fuel rich and complete oxidation of carbon monoxide and other species is accomplished in a second combustion stage arranged downstream of the MHD generator. Results from experimental and analytical studies of the NO$_x$–gas chemistry in MHD combustion gases are presented and it is shown that there is good correlation between experimental and analytical data. Analytical kinetic calculations of the NO$_x$ chemistry appropriate to central station power plant operation have also been performed indicating the practical utilization of the proposed technique to MHD power plant design. It is shown that two-stage combustion or afterburning is an effective technique for the reduction of nitrogen oxides concentration in MHD effluent stack gas below the recently adopted EPA emission rate limits. (auth)

**22393** NO CONCENTRATIONS IN MHD STEAM POWER PLANT SYSTEMS. Pepper, J. W.; Eustis, R. H.; Kruger, C. H. (Stanford Univ., CA). pp VI.6.1-VI.6.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

A flexible computer program was written to follow the decomposition of NO through an MHD-topped steam power plant. In the present cycle methane is burned with preheated air at a thermal input of 2000 MW. Potassium carbonate seed (1% K by weight) is used and for this first study the combustion pressure is 5.6 atm. One cycle with a stoichiometric air-fuel ratio and one cycle with an initial combustion stage of 87% theoretical air and stoichiometric ratio overall were compared. The combustion temperature for the first case is 2700°K and the combustion temperature for the two stage combustion cycle is 2751°K. Two stage combustion reduced the NO level at the plant exhaust from 1958 ppM to 283 ppM. In addition plant efficiency increased from 44.7% to 49.4%. The air preheater appears to have a very significant effect on the rate of decomposition of the NO. (auth)

**22394** KINETIC STUDY OF OXIDES OF NITROGEN IN MHD POWER PLANTS. Mori, Y. (Tokyo Inst. of Tech.); Ohtake, K.; Taira, T. pp VI.7.1-VI.7.6 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Concerning the SO$_2$ emission problem, MHD power plants have a superiority over conventional steam plants as seeded potassium is conveniently used as a desulferating material, and the only emission problem which MHD plants have to solve is that of nitrogen oxides. The kinetic behavior of oxides of nitrogen in a 1,000 MW MHD-steam combined power plant and the condition of the plant system required to make the emission of oxides of nitrogen as small as possible are described. The kinetics of nitrogen reduction are discussed. Ten gas phase reactions and one surface reaction for the decomposition of NO were adopted to examine the behavior of these components in the plant. A number of numerical experiments were performed to get the optimum conditions concerning the temperature distributions of the gas in the boiler and heat exchangers and the position of the introduction of the secondary air for complete combustion. (auth)

**22395** DESIGN STUDY OF SUPERCONDUCTING DIPOLE MAGNETS FOR MHD GENERATORS. Elsel, W. (Siemens Forschungslaboratorien, Erlangen, Ger.); Muntenbruch, H. pp VI.9.1-VI.9.8 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Various conductors, coil geometries, winding concepts, and design principles are compared for a superconducting dipole magnet with a magnetic induction $B = 5$ tesla for use in an MHD generator. The design selected is described together with the calculations of its magnetic field, forces, mechanical strength, and heat losses. The quench behavior is represented by means of computer simulations. (auth)

**22396** INVESTIGATION OF OPERATION OF DUCT OF MHD GENERATOR OF U-02 PLANT WITH "HOT" CERAMIC WALLS. Kirillin, V. A.; Sheindlin, A. E.; Shumyatskii, B. Ya.; Kirilov, V. V.; Burenkov, D. K.; Lubimov, G. A.; Pischikov, S. I.; Sokolov, Yu. N. (Inst. for High Temperatures, Moscow). pp LPS.3 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

Theoretical analysis and tests of MHD generators with "cold" and "hot" ducts show that from an electrical and thermodynamical viewpoint, the "hot" duct offers clear-cut advantages. With respect to the "cold" duct, the low temperature of the wall results in high heat losses, which decrease the internal relative efficiency of the MHD generator; also, formation of cold boundary layers on the electrodes reduces the amount of power produced. These disadvantages are especially evident in small- and medium-size MHD ducts. (auth)

**22397** INFLUENCE OF DEGREE OF EXTENSION OF ELECTRODES INTO FLUX ON LOCAL CHARACTERISTICS OF MHD GENERATORS. Vanin, V. E.; Kirillov, V. V.; Maslennikov, G. I.; Sokolov, Yu. N. (Inst. for High Temperatures, Moscow). pp LPS.5 of Engineering Aspects of Magnetohydrodynamics. Petrick, M. (ed.). Argonne, IL; Argonne National Lab. (1972).

From 12th symposium engineering aspects of magnetohydrodynamics; Argonne, IL (27 Mar 1972). See CONF-720342-.

A calculation is presented of the influence of the degree of extension of the electrodes into the flux on the local characteristics of the MHD generator, and compares some results of the calculation with experimental data. (auth)

**22398** ENERGY REQUIREMENTS OF THE FUTURE. Gaucher, L. P. Solar Energy; 14: No. 1, 5-10(Dec 1972).

In 1965 at a Solar Energy Society meeting in Phoenix, Arizona, it was predicted that a large amount of solar energy would be required in another 30 to 40 yr to supplement nuclear energy and the world's dwindling supply of fossil fuels. Since then, many things have occurred to reinforce this prediction and we are now six years closer to the time when solar energy will be needed. However, the research and development work that must be done before solar energy can take its place among other large sources of energy will be extensive and expensive. This work will have to be supported by the governments of the world, just as atomic energy was. Steps should be taken now to promote awareness of the ultimate need for solar energy and to promote the allocation of funds for the research and development work required. (auth)

**22399** LARGE SCALE SOLAR ELECTRIC POWER GENERATION. Ralph, E. L. (Textron, Sylmar, CA). Solar Energy; 14: No. 1, 14-20(Dec 1972).

The need for a new source of energy for generating electric power has been well established. This new energy source must be able to meet the many demands of our society in respect to resource depletion, increased electrical power requirements, peak demands, site location, low costs, and the elimination of pollution. The one energy source that provides a solution to these problems is solar energy. Although no significant effort or funds are being spent on solar energy research, there are indications that this energy could be tapped with present day technology. Some features are described of a large scale solar cell electric power generating system that could be built to show the feasibility of utilizing solar energy. The basic system components are described and an engineering analysis made of the electrical, optical, mechanical, and thermal characteristics of the system. (auth)

**22400** SOLAR DEPRESSION POWER PLANT OF QATTARA IN EGYPT. Bassler, F. (Technical Univ., Darmstadt, Ger.). Solar Energy; 14: No. 1, 21-28(Dec 1972).

In the Libyan Desert of North Africa, only 80 km away from the Mediterranean, a vast depression 300 km long and 150 km wide can be found, the floor of which at its lowest point lies 135 m below sea level. If seawater is conducted to the northern edge of this depression by an open channel or an underground supply line, the difference of elevation between the Mediterranean and the bottom of the depression can be used for generating power in water turbines. Although the depression has no outlet, the utilized water is subjected to very high evaporation from this area. Years of survey have shown an average remaining evaporation of 1800 mm per annum. Optimum efficiency of the power plant is achieved when equilibrium prevails between the amount of water flowing in and the amount evaporating by the sun's energy into the atmosphere. In the Qattara Depression near El Alamein this state can be achieved as soon as the water level has reached −60 m, corresponding to a surface area of 12,000 $km^2$ and to an annual evaporation volume of more than 20,000 million $m^3$. Thus a seawater discharge of at least 650 $m^3$/sec can be continuously fed into the turbines of the power plant without the level in the new Qattara Basin rising any further. The capacity attainable with this hydro-solar scheme combined with pumped storage reaches about 4,000 MW peak. (auth)

**22401** HELIOHYDROELECTRIC (HHE) POWER GENERATION. Kettani, M. A.; Gonsalves, L. M. (Coll. of Petroleum and Minerals, Dhahran, Saudi Arabia). Solar Energy; 14: No. 1, 29-39 (Dec 1972).

Solar energy can be efficiently converted into electricity by transforming it into hydraulic energy as in nature. This can be done "artificially" when the topographical and hydrological conditions are favorable. For instance, Dawhat Salwah of the Arabian Gulf (Persian Gulf) can be transformed easily into a large water reservoir, by building a dam from Saudi Arabia to Bahrain, and another from Bahrain to Qatar. Because of evaporation, the level of the "closed reservoir" will tend to decrease, inducing a flow to move from the "open sea," to restore the level to its initial value. Therefore the flow of water evaporated by the sun is transformed into a discharge from the "open sea" to the "closed reservoir." Solar energy of evaporation has thus been transformed into hydraulic energy. If a physical head, $H_e$, is set between the two levels the potential energy thus formed by the discharge, falling along $H_e$, could be transformed into electrical power. The value of this power is related to the physical and meteorological characteristics of the chosen "closed basin." The entire system is studied theoretically as an "electric generator" package, by maximizing parameters for optimum energy conversion efficiency. (auth)

**22402** SPACE TECHNOLOGY TRANSFER TO COMMUNITY AND INDUSTRY. Proceedings of the AAS Eighteenth Annual Meeting and the Tenth Goddard Memorial Symposium, Washington, D. C., March 13–14, 1972. Tripp, R. H.; Stotz, J. K. Jr. (eds.). Science and Technology Series, Volume 29. Tarzana, CA; American Astronautical Society (1972). 193p. (CONF-720343–).

Eighteen papers were presented at the conference. A separate abstract was prepared for one paper. The remaining papers on space technology transfer, community and industrial challenges to aerospace technology, the coming crisis in health care, and transportation in the year 2000 were not within the scope of NSA. (RCK)

*For an abstract of an individual paper see: 22403.*

**22403** NEW ENERGY TECHNOLOGY. Balzhiser, R. E. (Office of Science and Tech., Washington, DC). pp 145-156 of Space Technology Transfer to Community and Industry. Tripp, R. H. (ed.). Tarzana, CA; American Astronautical Society (1972).

From Proceedings of the AAS eighteenth annual meeting and the tenth Goddard memorial symposium; Washington, DC (13 Mar 1972). See CONF-720343–.

The technological options which appear to be feasible for the future development of energy resources are discussed. Technological objectives must include making available additional energy reserves and utilizing them more efficiently and with minimal environmental degradation. The President's energy message to Congress is discussed. The Federal effort on the Liquid Metal Fast Breeder Reactor is singled out for priority treatment. Other areas designated by the President for increased attention includes coal gasification and more efficient use of oil and gas resources. Another program designated by the President for immediate attention is $SO_2$ control technology. This program has as its aim the elimination of $SO_2$ in the atmosphere from the burning of high sulfur fuels in large central power stations. Other methods for energy generation are discussed, e.g., MHD, fuel cells, nuclear stimulation of natural gas, geothermal energy, and solar energy. (RCK)

**22404** ELECTRODE AND GASDYNAMIC EFFECTS IN A LARGE NONEQUILIBRIUM MHD GENERATOR. Zauderer, B.; Tate, E. (General Electric Co., King of Prussia, PA). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 11: No. 2, 149-155 (Feb 1973).

An experimental study was performed to determine the factors limiting the power output of a linear, supersonic Faraday generator, having electrodes suspended in the gas flow. The test gases were cesium seeded neon or argon at 2000 to 4000°K stagnation temperatures and 5 to 11 MW thermal power levels. It was observed that the electrode current varies directly with the cesium concentration for electrode current densities of the order of tens of amp/cm$^2$. The electrode current was nearly independent of electrode temperature and surface area. It was concluded that the electrode conduction was due to the cesium ion flux at the cathode. The gasdynamic characteristics of the generator as deduced from pressure and Mach number measurements were in fairly good agreement with the theory based on the one-dimensional gas conservation equations. At electromagnetic interaction parameters in excess of 0.4, oblique shock waves were detected in the generator. The shock waves did not noticeably influence the power output. At 2150°K, 8.5% of the thermal power was converted to electric power at the external load. An equivalent amount of power was dissipated internally at the electrodes, primarily at the cathode. It is concluded that by using a larger MHD channel or by operating at higher gas pressure, cesium concentrations, and magnetic field strengths, 20% heat to electric conversion ratios should be readily attainable. (auth)

**22405** MAGNETOHYDRODYNAMIC CONVERSION EXPERIMENTS WITH NONEQUILIBRIUM IONIZATION. Caressa, J. P.; Bouesc, J. (Univ., Aix-Marseille). Compt. Rend., Ser. A, B; 275: No. 25, 1387-1390(18 Dec 1972). (In French).

Magnetohydrodynamic conversion experiments were carried out using a supersonic flow of ionized argon. This flow was produced by a shock wave propagated through the test tube of a combustion shock tube. The principal purpose of the experiments was to investigate the increase in the energy of the electron gas in relation to the energy of the heavy particles under the effect of the induced electric field. (FR)

**22406** ELECTRICAL FIELD IN THE CROSS SECTION OF A HALL MHD GENERATOR DUCT. Medin, S. A.; Rutkevich, I. M. Zh. Prikl. Mekh. Tekh. Fiz.; No. 1, 3-10(1973). (In Russian).

An accurate solution was obtained for the transverse two-dimensional problem for the case of a duct with an elliptical cross section stretched out along a magnetic field. A parametric model distribution of the electrical conductivity of the boundary layer type was assumed. The dependencies of the electric field and the current, and also the integral electrical characteristics of the generator were analyzed as functions of nonuniformity parameters. (tr-auth)

**22407** THERMIONIC GENERATORS. Bito, J. Musz. Tud.; 45: No. 3-4, 315-329(1972). (In Hungarian).

The properties of thermionic generators and methods for their classification are discussed, thus pointing out the more important types of these generators. The experience gained with only few tests in heading traditional thermal power stations as well as atomic power stations is summarized. The state of R and D is characterized by presenting thermionic generators used in the ITR system, analyzing the characteristic relations between their more important parameters, e.g., efficiency, emitter temperature, output power, and specific mass. The more important research trends in classification according to the usual surface and volume phenomena are reviewed. (auth)

## Facilities and Equipment

*Refer also to abstracts 22326, 22846, and 24172.*

**22408** (KFK-1686) SINEX: PROGRAM SYSTEM FOR THERMAL AND MECHANICAL DESIGN OF SODIUM HEATED INTERMEDIATE HEAT EXCHANGERS. Schnauder, H. (Kernforschungszentrum, Karlsruhe (West Germany). Institut Fuer Reaktorentwicklung). Dec 1972. 219p. (In German). Dep. NTIS (U. S. Sales Only) $13.00.

SINEX, a computer program for the thermal and mechanical design of sodium/sodium intermediate heat exchangers for steady-state design conditions is described. The relatively simple input and easily interpreted output make the system suitable also for parameter studies and optimization calculations. In addition to the usual print output, the results calculated may be plotted in diagrams and a simplified cross section of the heat exchanger may also be plotted. In parameter calculations the influence of the different parameters can also be plotted in diagrams by the computer. The high flexibility of the program enables the system to be extended or modified easily in order to meet individual requirements. (auth)

**22409** (RFP-2006) BLAST SUPPRESSING BOMB TRANSPORT VEHICLES. Thomas, S. G.; Brannum, R. G.; Hert, A. C.; Domning, W. E. (Dow Chemical U.S.A., Golden, Colo. Rocky Flats Div.). 5 Feb 1973. Contract AT(29-1)1106. 9p. Dep. NTIS.

Two transport vehicles were designed and tested for use in the safe removal of a bomb or other explosive devices from an industrial plant. These vehicles consist of a cart and a trailer. A device consisting of 8 sticks of 40% dynamite may be safely destroyed in the trailer. An explosion of 25 sticks of 40% dynamite should not seriously damage the trailer. The transport cart resisted the effects of one stick of 40% dynamite under test. Approximately 4 sticks of dynamite would be required to destroy the cart. (auth)

**22410** COMPUTER PROGRAMME FOR HEAT EXCHANGER CALCULATIONS. Guelich, J. (Winterthur Engineering Works Div., Switzerland). Sulzer Tech. Rev.; No. Nuclex 72, 81-88 (1972).

A computer program for making heat exchanger calculations for arriving at optimum design parameters is described. (TFD)

**22411** COMPARISON BETWEEN PANDYNE, A NON-LINEAR DIGITAL PROGRAMME FOR THE ANALYSIS OF BOILER DYNAMICS, AND TESTS ON SEVERAL ONCE-THROUGH BOILERS. Jaeger, J. F. (Winterthur Engineering Works Div., Switzerland). Sulzer Tech. Rev.; No. Nuclex 72, 63-72(1972).

The PANDYNE program has been developed over the past few years to calculate large transients in a steam generator considering non-linear effects, and yet be suitable for computing step responses for control studies. Apart from the description of some of the essential features of this program, a comparison with experimental results from several full size boilers is presented. (auth)

**22412** FRETTING IN TUBE SUPPORTS OF HEAT EXCHANGERS. Fricker, H. W. (Winterthur Engineering Works Div., Switzerland). Sulzer Tech. Rev.; No. Nuclex 72, 55-62(1972).

Primary heat exchangers for high-temperature reactors must be designed for a life of 30 years. Maintenance is normally only possible for the peripheral items, not for the heat exchanger surface. All inside components, among them the tube supports, must be maintenance-free. The relatively high dynamic gas forces tend to set up tube vibrations. These again cause relative movement and wear, or "fretting," at the tube supports. Limiting these vibrations to an acceptable level is a design problem. A simplified vibration analysis permits the amount of fretting wear produced to be determined by assuming purely frictional damping. Thereby specific wear rates obtained in fretting tests are used. The results of such fretting tests under the prevailing conditions are given. An example shows how several important tube support properties can be obtained by a relatively simple design. (auth)

## Heat Transfer and Fluid Flow

*Refer also to abstracts 22362, 22364, 22366, 22408, 22410–22412, and 22550.*

**22413** (EURFNR-1042) INVESTIGATIONS OF THE TURBULENCE AND SHEAR STRESS DISTRIBUTION IN A CIRCULAR CHANNEL WITH A HOT-WIRE ANEMOMETER. Rehme, K. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Neutronenphysik und Reaktortechnik). Jul 1972. 39p. (KFK-1642). Dep. NTIS $4.00.

Work performed under United States–Euratom fast reactor exchange program.

To use a DISA hot-wire anemometer for the experimental investigation of shear stress and turbulence of turbulent flow a test was performed in a circular channel. For circular tubes the shear stress distribution can be obtained theoretically and, besides, a number of papers is known in the literature communicating the measurements of turbulence intensities. The measurements were conducted for Reynolds numbers ranging between $2 \times 10^4$ and $2 \times 10^5$ at a position of 75 tube diameters. The experimental results of the shear stress distribution are in excellent agreement with the theoretical values; the experimental turbulence intensities are in very good agreement with the data published in the literature. (auth)

**22414** (LIB/Trans–440) STUDY OF THE EXCITATION OF HYDRODYNAMIC VIBRATIONS IN A SIMPLE ROD MODEL IN AXIAL WATER FLOW. Ohlmer, E.; Russo, S.; Schwemmle, R. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Translation of EUR–4771. 1972. 28p. Dep. NTIS (U. S. Sales Only) $3.50.

An analytical model for parallel flow-induced vibrations was experimentally checked on a single rod test facility in a water loop. Especially, the influences of simplification hypothesis in the analytical model and of loop-caused disturbances in the flow were considered. The tests show that the analytical model is useful also for application in the case, that pump or valve-induced noise is present in the flow. Furthermore, it has been seen that the simplifying assumption of an "homogeneous pressure field" over the beam length tends to overestimate the exciting pressure forces. Measurements of the pressure-difference-fluctuations on the rod surface have given some results for characterizing the pressure field in the present flow geometry, both for undisturbed established flow and for the flow in the entrance zone. External noise in the flow, e.g., induced by circulation pumps, can increase by an important factor the pressure differences and corresponding rod vibrations. The actual study will continue with similar tests on a rod-bundle geometry. (auth)

**22415** THERMAL INSTABILITY IN A VISCOELASTIC FLUID LAYER IN HYDROMAGNETICS. Bhatia, P. K.; Steiner, J. M. (Monash Univ., Clayton, Australia). J. Math. Anal. Appl.; 41: No. 2, 271-283(Feb 1973).

Overstability in a horizontal layer of a viscoelastic fluid is considered in the presence of a uniform magnetic field. The equations of motion appropriate to hydromagnetics in a Maxwellian fluid have been established and the analysis has been carried out in terms of normal modes. The proper solutions have been obtained for the case of two free boundaries. The dispersion relation obtained is found to be quite complex and involves the Prandtl number $p_1$, magnetic Prandtl number $p_2$, a parameter Q characterizing the strength of the magnetic field, and a parameter Q characterizing the strength of the magnetic field, and a parameter $\Gamma$ which characterizes the elasticity of the fluid. Numerical calculations have been performed for different values of the parameters involved and the values of critical Rayleigh numbers, wave numbers, and frequencies for the onset of instability as overstability have been obtained. It is found that the magnetic field has a stabilizing influence on the overstable mode of convection in a viscoelastic fluid. Elasticity is found to have a destabilizing influence as in the absence of a magnetic field. Thus the effect of a magnetic field is the same as that for an ordinary viscous fluid. (auth)

**22416** MASS TRANSFER IN TURBULENT FLOW. Larson, R. I.; Yerazunis, S. (Rensselaer Polytechnic Inst., Troy, NY). Int. J. Heat Mass Transfer; 16: No. 1, 121-128(Jan 1973).

The local mass transfer coefficient in turbulent duct flow was measured using a new experimental technique. The experimental results agreed quite well with a numerical solution to the turbulent diffusion equation in channel flow. Formulation of the diffusion equation provided a continuous solution from a point near the discontinuity in mass flux to the fully developed region. The Nusselt numbers obtained numerically agreed with Spalding's asymptotic solution at $x/D_h < 0.02$ and the eigenvalue solution of Hatton et al, for symmetrical heat transfer which is valid for $x/D_h > 1$. Current asymmetric heat transfer results in the fully developed region fell between the eigenvalue and numerical solutions. (auth)

**22417** APPROACH TO THE ANALYSIS OF TEMPERATURE FLUCTUATION IN TWO-PHASE FLOW. Afgan, N.; Jovanovic, L. J.; Stefanovic, M.; Pislar, V. (Boris Kidric Inst. of Nuclear Science, Belgrade). Int. J. Heat Mass Transfer; 16: No. 1, 187-194(Jan 1973).

An approach to the analysis of temperature fluctuation in a two-phase system is presented. It is assumed that the resulting temperature fluctuation in a two-phase boiling boundary layer can be divided into two independent fluctuating functions. One is the square wave function obtained as a result of crossing the liquid-vapor interface and the other represents the random fluctuation of temperature in water and vapor. Taking this assumption into consideration the resulting variance of temperature fluctuation is the sum of the variances of these independent functions. Experimental verification of this approach is obtained by amplitude and frequency analysis of the microthermocouple signal placed at different positions from the heating wall. It is shown that the presented approach of the analysis of temperature fluctuation is in fair agreement with the experimental measurement. (auth)

**22418** EXPERIMENTAL STUDY OF NATURAL CONVECTION IN VERTICAL CELLS OF RECTANGULAR CROSS SECTION. Jannot, M.; Mazeas, C. (Societe Bertin et Compagnie, Plaisir, France). Int. J. Heat Mass Transfer; 16: No. 1, 81-100(Jan 1973). (In French).

The synthesis of experimental measurements achieved in order to delimit the type of flow in laminar and turbulent free convection in vertical cells of rectangular cross section is presented. Some correlations are proposed to determine the mean Nusselt number in the high Rayleigh number region. (auth)

**22419** INVESTIGATION INTO THERMAL BOUNDARY LAYER GROWTH IN THE ENTRANCE REGION OF AN ANNULUS. Srivastava, N. C.; Bakhtar, F.; Bannister, F. K. (Univ. of Birmingham, Eng.). Int. J. Heat Mass Transfer; 16: No. 1, 49-59(Jan 1973).

An experimental investigation into the effect of an unheated length and the annulus ratio on the variations in heat transfer coefficient in the early entrance region of an annulus is described. The shape of the unheated section is shown to have a great influence in the first 1 to 2 equivalent diameters from the leading edge but thereafter the results approach the values corresponding to the fully developed conditions rapidly. The effect of high heater-to-fluid temperature ratios is also investigated and it is shown that the results are not adequately covered by the correlations commonly in use in the literature. (auth)

**22420** AEROSOL TRANSPORT IN A NATURALLY-CONVECTED BOUNDARY LAYER. Hales, J. M.; Schwendiman, L. C.; Horst, T. W. (Battelle-Northwest, Richland, Wash.). Int. J. Heat Mass Transfer; 15: No. 10, 1837-1850(Oct 1972).

Aerosol deposition to an isothermal vertical surface through naturally-convected boundary layers is analyzed. Both laminar and turbulent boundary layers, and condensing and noncondensing systems are considered. The general approach is to utilize a heat-transfer analogy to predict deposition in limiting cases of zero and predominant aerosol diffusion. These limiting results are then combined in an attempt to predict nonlimiting behavior. Comparison with computed results from a more refined boundary-layer analysis of the steam–air system shows reasonable agreement for most situations involving laminar flows. No such comparison is possible for the turbulent regime, owing to the absence of related work in the field. The equations presented are suggested for use in engineering estimates and as a means of correlating future related results of an experiment nature. (auth)

**22421** BUBBLE GROWTH AND COLLAPSE IN NARROW TUBES WITH NONUNIFORM INITIAL TEMPERATURE PROFILES. Ford, W. D. (American Oil Co., Whiting, IN); Bankoff, S. G.; Fauske, H. K. Int. J. Heat Mass Transfer; 15: No. 10, 1953-1956(Oct 1972).

Experimental data are presented for both slug expulsion and reentry of Freon-113 in vertical tubes with non-uniform initial temperature. Previous work is extended to take into account the effect of film thickness and also the non-uniform initial condition. (UK)

**22422** DYNAMICS OF AXIAL HEAT TRANSFER WITH TURBULENT FLOW IN A TUBE. Schmidl, H. (Oesterreichische Studiengesellschaft fuer Atomenergie GmbH, Seibersdorf). Int. J. Heat Mass Transfer; 16: No. 1, 13-23(Jan 1973). (In German).

In turbulent flow in a tube, heat transfer occurs by convection as well as by thermal diffusivity and eddy diffusivity for heat. Experiments show, however, that after a temperature disturbance at the tube entry is induced, an extraordinary fast temperature equalization is obtained in an axial direction. This cannot be explained by the latter two of the effects previously mentioned. An additional heat transfer mechanism must occur. Considering the effect in a coordinate system, which moves with average flow speed in an axial direction, the location of the disturbance seems to remain in place. Two liquid layers with counter flow can be distinguished in the tube. Assuming a fictitious wall between the two layers, a model of a counter flow heat exchanger is obtained. The heat transfer does not therefore occur through the cross-section of the tube but along the much bigger surface of the fictitious wall. This explains the fast temperature equalization which is found by measurement. (auth)

**22423** THEORY OF THE ULTIMATE HEAT TRANSFER LIMIT OF CYLINDRICAL HEAT PIPES. Busse, C. A. (Joint Nuclear Research Center, Ispra, Italy). Int. J. Heat Mass Transfer; 16: No. 1, 169-186(Jan 1973).

Axial heat flux in heat pipes is limited, in principle, because of insufficient return flow of condensate and vapour flow limitations. If the liquid return flow is guaranteed by a suitable wick design, it is ultimately limited only by vapour flow effects. For this ultimate limit of heat transfer several vapour flow regimes can be distinguished depending on the relative magnitude of inertia and viscous forces in the vapour. An analysis of the ultimate limit of heat transfer of cylindrical heat pipes with laminar vapour flow is presented for the two limiting cases of either predominant inertia- or viscous forces (inertia and viscous flow regime), taking into consideration both the axial and radial variation of the vapour velocity. The radial variation of axial velocity is decisive in the viscous flow regime, while in the inertia flow regime its influence is limited to a 5% decrease of the ultimate limit of heat transfer. The vapour is described as an isothermal perfect gas. In the pressure ranges of interest this model presents a fair approximation to reality (error in the heat transfer limits of about 10%) and results in a very simple analysis. In the inertia flow regime, the heat flux is limited by the choking phenomenon (sonic heat transfer limit), and in the viscous flow regime by the fact that the vapour pressure cannot be smaller than zero (viscous heat transfer limit). Approximate formula are derived for each case. The analysis shows that for every heat pipe below a certain temperature the ultimate limit of heat transfer is of the viscous type. This limit can lie far below the sonic limit. Good agreement is found between theory and experimental data. (auth)

## Materials Testing

*Refer also to abstracts 22474, 22856, 22857, 22923, 24169, and 24172.*

**22424** (BNWL-SA-3942) DEVELOPMENTS IN LOW-FLUX NEUTRON RADIOGRAPHY AT BATTELLE-NORTHWEST. Swinth, K. L. (Battelle Pacific Northwest Labs., Richland, Wash.). Oct 1971. Contract AT(45-1-)1830. 32p. (CONF-711008-7). Dep. NTIS $3.75.

From 19th conference on remote systems technology; Miami Beach, Florida, USA (17 Oct 1971).

The use of isotopic sources for neutron radiography generally requires that imaging be performed in low fluxes of thermal neutrons ($\sim 5 \times 10^3$ n/cm$^2$ sec). To effectively utilize such low fluxes, one must optimize the source-collimator configuration and the imaging techniques. Efforts directed toward utilization of $^{252}$Cf in portable low-flux neutron radiography are discussed. Developments in both source holder-exposure facility design and imaging techniques are reported. (auth)

**22425** (NASA-SP-5952-2) TESTING METHODS AND TECHNIQUES: QUALITY CONTROL AND NONDESTRUCTIVE TESTING. A Compilation. (National Aeronautics and Space Administration, Washington, D. C.). 1973. 25p. Dep. NTIS $4.00.

A variety of devices and techniques developed by AEC and NASA, useful in nondestructive testing are described. Ranging in complexity from an automated ultrasonic testing system designed for inspecting complex laminated honeycomb structures, to a flexible leak detector probe, the items represent either potential savings in cost and time, or improvement in inspection quality over past techniques. The items are presented in three sections, dealing with weld and braze inspection, leak detection, and inspection of composite materials. (TFD)

**22426** WIRE IMAGE DISTRIBUTION AND ITS DISCERNIBLE LIMIT IN THE GAMMA-RAY RADIOGRAPHY. Using Visual Response. Nojiri, T. (Industrial Research Inst. of Kanagawa Prefecture, Yokohama, Japan). Hihakai Kensa; 21: No. 10, 605-610(Oct 1972). (In Japanese).

The modulation transfer function (MTF) technique based upon Fourier transform can be applied effectively to a $\gamma$-ray radiographic system in analyzing the formation and transfer of the image. The spectrum of the image on the film is finally obtained by combining the MTF of some stage. The distribution function or the form of the object image can be estimated from this by means of the inverse Fourier transform. Radiographic image of wires of circular cross section is calculated. The effect of scattering ray from the object is introduced in terms of the direct beam dose ratio. Also the image of a wire-shaped image quality indicator is calculated using approximate visual response, and compared with experimental I.Q.I. detectability to examine the discernible limit. The results show that there are regions where the image contrast multiplied by the width of the image is constant. (auth)

**22427** MANUAL OF NON-DESTRUCTIVE TESTING. Second Edition. London; Central Electricity Generating Board (1971). 200p.

The subject is dealt with in chapters: visual methods; replica method; penetrant liquid and gas leak method; magnetic methods; electrical methods; principles of ultrasonics; techniques of ultrasonic testing; equipment for ultrasonics; interpretation of ultrasonic data; applications of ultrasonics; principles of radiography (basic properties of x rays and gamma rays, generation of x rays and gamma rays, geometric factors controlling definition, beam direction, marking out, image quality indicators); equipment for radiography (essential features of x-ray equipment, kilovoltage of x rays required, gamma-ray equipment, choice of gamma-ray source); photographic aspects of radiography; techniques of radiography (principles, film viewing, radiographic definition, radiographic contrast, general procedure in defining techniques); new developments in the design of image quality indicators; interpretation of radiographs; applications of radiography; recent developments in radiography (radiography on film, radiography on paper, non-photographic recording methods, fluoroscopy, electronic image intensifiers, solid-state image intensifier panels, combination techniques, neutron radiography, counters and ionization methods); some limitations of radiographic techniques; testing of non-ferrous metals. The manual includes an appendix on radiological safety, and a glossary of terms used in non-destructive testing. (UK)

**22428** NEUTRON RADIOGRAPHY USING THERMAL NEUTRONS WITH A DEUTERON ACCELERATOR. Vu Hong; Breynat, G. (CEN, Grenoble, France). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), Suppl.; No. 90, 21-25(1971). (In French).

A small ion accelerator was used as a thermal neutron source, decelerated fast neutrons obtained from a deuterium–tritium reaction being used. It is necessary to optimize the geometry of the source-moderator-collimator assembly if a good quality thermal neutron beam is to be obtained at the collimator output; the best results are obtained with the natural uranium-light water system. Neutron radiographs of a test object obtained using two systems, one of which being optimized, are presented. Examples of applications in the nuclear and aerospace industries are presented. (FR)

**22429** INDUSTRIAL APPLICATIONS OF NEUTRON RADIOGRAPHY. Settipani, A. (Societe Qualitest, Levallois-Perret, France). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), Suppl.; No. 90, 10-11(1971). (In French).

The neutron absorption coefficients of various materials (dense or thick materials, light materials, and composite materials) determine the range of applications of neutron radiography techniques. The industrial application neutron radiography equipment (utilizing 0.5 eV neutrons) used in conjunction with Triton is described. Various industrial developments are presented. (FR)

**22430** NON-DESTRUCTIVE EXAMINATION OF PIPE WELDS. Wunder, C. A. (Power Piping Co., Pittsburgh). Power Eng.; 77: No. 3, 56-59(Mar 1973).

The four nondestructive testing methods, dye penetrant, magnetic particle, radiographic, and ultrasonic, for inspecting pipe welds are briefly explained and compared as to type of defects detectable, weld surface treatment requirements, performance limitations, and recordability of results. (LCL)

**22431** GENERAL PRINCIPLES OF NEUTRON RADIOGRAPHY. Boutaine, J. L. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), Suppl.; No. 90, 8-9 (1971). (In French).

Existing neutron radiography installations enable nuclear fuel materials and structural materials to be examined during in-pile irradiation. The principles of neutron radiography in which an incident neutron beam traverses the object under investigation and is collected by a detector are given. The techniques used to obtain images in neutron radiography are discussed. (FR)

**22432** SOURCE UTILIZING NEUTRON PULSES PRODUCED BY A SUDDEN INCREASE IN THE REACTIVITY OF A HOMOGENEOUS REACTOR. Houelle, M. (Centre d'Etudes de Valduc, Is-sur-Tille, France). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), Suppl.; No. 90, 14-20(1971). (In French).

The production of neutrons from a supercritical fissile liquid medium allowed to evolve freely after a momentary excess of reactivity is considered. The equipment, which consists principally of a tank containing the fissile liquid and neutron reflectors, is described. The equipment is buried in a concrete biological protection and provided with two types of neutron radiography collimator. From the operational point of view, the neutron power increases when the chain fission reaction triggers in the fissile medium; after triggering, the neutron power decreases. The safety aspects of the apparatus are discussed. The CRAC program was used to examine criticality accidents in uranium solutions. The nuclear characteristics (especially critical mass) and the performance of the equipment are presented. The results obtained with an experimental apparatus are given together with a neutron radiography model for irradiated fuel elements. (FR)

**22433** NEUTRON RADIOGRAPHY. Medveczky, L. (MTA Atommag Kutato Intezete, Bedrecen, Hungary). Izotoptechnika; 16: No. 1, 1-15(Jan 1973). (In Hungarian).

The principles and applications of neutron radiography are discussed. Equipment and methods for nondestructive testing using neutron radiography are summarized. (auth)

**22434** DEVELOPMENT AND FUTURE OF THE USE OF NEUTRON RADIOGRAPHY IN CZECHOSLOVAKIA. Hrdlicka, Z. (Inst. for Nuclear Research, Rez, Czech.). Izotoptechnika; 16: No. 1, 16-20(Jan 1973). (In Hungarian).

The planning for a new irradiation channel in the VVR-S reactor is discussed. The SR-OA reactor has been used as a neutron source for the radiography of reactor channels and spent fuel elements. The further development and fabrication of new neutron sources are summarized. (auth)

**22435** PRESENT STATUS OF INDUSTRIAL RADIOLOGY. Halmshaw, R. (Royal Armament Research and Development Establishment, Fort Halstead, Eng.). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), Suppl.; No. 92, 8-10(1971). (In French).

The problem of training industrial radiology personnel and persons inspecting the photographic records is discussed. Radiographic examination involves producing photographic records, interpreting the image formed (or reading the film), and the possible accepting of the faults detected by the radiographer. The various equipment used in conjunction with the radiography apparatus is reviewed, i.e., automatic carriage carrying x-ray equipment fed by accumulators; advanced type linear accelerators; and radiography apparatus with television. Polaroid, color, or cinematographic films are used in parallel with radiographic films. The utilization of $\gamma$ radiation for small thickness where the use of x rays is difficult or impossible is currently under investigation. (FR)

**22436** VORTRAGSTAGUNG 1972 ZERSTOERUNGSFREIE MATERIALPRUEFUNG, SAARBRUECKEN, 9—10 MAI 1972. (Nondestructive materials testing. 1972 Conference held at Saarbruecken, Germany, May 9–10, 1972). Berlin; Deutsche Gesellschaft fuer Zerstoerungsfreie Pruefverfahren e. V. (1972). 36p. (CONF-720577–(Absts.)).

From Conference on nondestructive materials testing; Saarbruecken, F.R. Germany (9 May 1972).

Abstracts of papers presented at the conference on nondestructive materials testing at Saarbruecken, Germany, May 8 to 10, 1972 are presented. (TFD)

**22437** OUTLOOK AND FUTURE OF THE LECI (LABORATOIRE d'ETUDES DES COMBUSTIBLES IRRADIES) CONCERNING NONDESTRUCTIVE TESTING FACILITIES FOR IRRADIATED FUELS AND MATERIALS. Fignon, M.; Mansard, B.; Roussel, E. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 174, 7-13(Oct 1972). (In French).

Since its establishment in 1959, and particularly in recent times, the LECI (Laboratoire d'Etudes des Combustibles Irradies) has concentrated on acquiring nondestructive testing facilities and sufficient experience to enable most of the problems likely to arise from the irradiation of nuclear fuels and materials to be studied. The equipment available includes classical testing facilities such as radiography, metrology, and means for checking the fluid-tightness of apparatus. Means for visual examination and particular nuclear techniques such as $\gamma$ spectrometry are also available. (FR)

## Nuclear Explosions

*Refer also to abstracts 22340 and 22601.*

**22438** (AD–749341) EFFECTS OF STRONG EXPLOSIONS. IV. (Soviet Literature Translations). Kassel, S. (Rand Corp., Santa Monica, Calif.). Jun 1972. Contract DAHC15-67-C-0141. 90p. (R–760/3-ARPA). NTIS.

English-language abstracts of 66 articles from Soviet technical literature on the effects of strong explosions, particularly nuclear explosions, and their simulation in the laboratory and in the field are presented. The fourth in a series, this report covers articles mainly appearing in 1971 and early 1972. The abstracts are grouped under 13 headings, plus a miscellaneous category: nuclear explosion effects, explosions in various media, shock waves in gases, shock waves in liquids, shock waves in solids, flow past bodies, ablation studies, high-pressure effects, electromagnetic field-plasma interaction, ionospheric effects, radiation damage, laser effects on materials, and mechano-electromagnetic effect. (auth)

**22439** (AD-850352) APPLICATION OF A VERTICAL STRAIN SEISMOGRAPH TO THE ENHANCEMENT OF P WAVES. Shopland, R. C.; Kirklin, R. H. (Geotech, Garland, Tex). 12 Mar 1969. Contract F33657-68-C-0948. 41p. NTIS.

Enhancement of p waves is obtained by the suppression of microseisms with a combination of vertical linear strain seismograph and vertical inertial seismograph outputs. Significant suppression is observed at sites where the predominant microseisms consist of essentially single-mode Rayleigh waves in contrast to that observed at a site where the microseismic noise is compositionally more complex. (auth)

**22440** (AWRE-O-65/72) SOME SEISMIC RESULTS OF THE CANNIKIN UNDERGROUND EXPLOSION AT AMCHITKA, ALEUTIAN ISLANDS. Gibbs, P. G.; Blamey, C. (Atomic Weapons Research Establishment, Aldermaston (England)). Dec 1972. 32p. Dep. NTIS (U. S. Sales Only)) $3.75. UK 1 £.

Cannikin was a large nuclear explosion (about 5 megatons), fired underground on Amchitka in the Aleutian Islands, Alaska. The detonation occurred on Nov. 6, 1971 and the cavity it created collapsed on Nov. 8, 1971. Because the explosion is one of the largest to take place underground, and recordings were made over an unusually wide band of the seismic spectrum, the events are of special interest. The basic seismic data from these events, recorded by a UKAEA R and D facility at Wolverton in southern England, a temporary UKAEA recorder on Ascension Island, the Hagfors long-period array in Sweden and the 4 UKAEA type arrays are presented. (auth)

**22441** (EERL-TR-E-72-16) ESTIMATING WATER-SHOCK-INDUCED AIRBLAST FROM DETONATIONS IN A MEDIUM OVERLAIN WITH WATER. Snell, C. M. (Army Engineer Waterways Experiment Station, Livermore, Calif. (USA). Explosive Excavation Research Lab.). Apr 1972. 65p. Dep. NTIS.

A geometric shock wave transmission model was used to determine water surface peak spall velocities above single-charge cratering detonations in a medium overlain by a thin-to-moderately-thick layer of water. These velocities, in conjunction with an acoustic simple source treatment, predict the water-shock-induced airblast from such events. Required input data include the acoustic impedance and shock wave transmission properties of the cratering medium in the inelastic and elastic regions. The method is intended to predict far-field airblast in the "low" overpressure regime, for which case the acoustic simple source treatment is valid. This regime is of direct interest in determining airblast damage from typical explosive cratering events. The method is expected to be less accurate for extremely high overpressure levels and supersonic peak spall velocities, which require nonacoustic analysis. A computer code, MULTIMEDIA, is included as an aid to numerical prediction calculations. Predictions made using the code are compared with the limited airblast data available for underwater cratering tests. Results indicate that the basic assumptions of the method are correct. Further improvements in the prediction scheme and input parameters will be possible as more data become available. (auth)

**22442** (EERL-TR-E-72-32) ANNOTATED BIBLIOGRAPHY OF EXPLOSIVE EXCAVATION RELATED RESEARCH. (Army Engineer Waterways Experiment Station, Livermore, Calif. (USA). Explosive Excavation Research Lab.). Jul 1972. 229p. Dep. NTIS $3.00.

This bibliography contains a description of all reports prepared by the USAEC Nuclear Cratering Group (NCG), the USAE Waterways Experiment Station Explosive Excavation Research Office (EERO), and the USAE Waterways Experiment Station Explosive Excavation Research Laboratory (EERL) from Fiscal Year 1962 through Fiscal Year 1972. The reports address themselves to the many topics associated with the use of chemical and nuclear explosives in excavation projects, and each is described by a brief summary or abstract. Indexing is by subject, author, title, and report number. (auth)

**22443** (NVO-125) PLANNING AND OPERATIONS DIRECTIVE, PROJECT RIO BLANCO. (Nevada Operations Office (AEC), Las Vegas). Feb 1973. 44p. (PNE-RB–35). Dep. NTIS $4.25.

This Planning and Operations Directive sets forth authorities, procedures, responsibilities, concepts, plans, and reports to be used by the AEC's Nevada Operations Office in the fielding of Project Rio Blanco, a Plowshare experiment. It will also serve as the Operations Order providing for field execution of Project Rio Blanco. (auth)

**22444** (NVO-1163-10(R)) SUMMARY REPORT OF PREDICTIONS: DRIBBLE SERIES. (Beers (Roland F.), Inc., Alexandria, VA). 15 Jun 1964. Contract AT(29-2)1163. 87p. Dep. NTIS.

Project Dribble includes several contained high-energy explosions detonated in the Tatum Salt Dome in Mississippi for the purpose of studying the seismic effects of underground explosions. Information is given on the site geology and hydrology, cavity and chimney characteristics, hazards to nearby structures, and ground motion predictions based on revised data for Project Dribble. (LCL)

**22445** (PNE-R-60) PROJECT RULISON, PHASE II, FINAL REPORT. (CER Geonuclear Corp., Las Vegas, Nev.). 28 Dec 1972. Contract AT(26-1)-429. 90p. Dep. NTIS $6.50.

The preparations for and results of the Rulison Project for studying the feasibility of using underground nuclear explosions to stimulate the production of natural gas are summarized. Results of the reentry program are not included. Information is included on the historical background, project objectives, safety and documentation program, explosive operations, support program, damage claims, project logistics, costs, manpower management, and schedule of events. Synopses of 40 previous Rulison reports are presented in the appendix. (LCL)

**22446** (TID-26272) HOLE SPRINGING. Technical Report E-72-24. Gillespie, R. H. (Army Engineer Waterways Experiment Station, Livermore, Calif. (USA). Explosive Excavation Research Lab.). Jun 1972. 33p. (E-72-24). Dep. NTIS.

Hole springing tests were executed during the period July 1969 through September 1971 in five different media—coral, clay shale, weathered granite, unweathered granite, and interbedded sandstone and shale—to investigate the feasibility of constructing cratering charge emplacement cavities. Hole springing is defined as enlarging the bottom of a drill hole by successive detonations of small explosive charges. It was found that hole springing is most effective in compressible media, such as clay shale, for creating charge cavities. However, to be effective the springing charge must be kept small and the number of detonations in any one hole must be limited. Even when both of these criteria are met there will be some percentage of hole loss. Therefore, when an explosive excavation design depends on a precise cratering charge location and siz hole springing does not appear to be economical or feasible. However, hole springing can be effectively utilized for increasing the size of the charge that can be placed in a quarrying or mounding borehole. The burial depth below which hole loss and surface disruption were minimized was determined to be 7 to 9 $\text{ft/lb}^{1/3}$. The highest rate of hole survivability resulted from the use of water stemming during springing detonations. (auth)

**22447** SEQUENTIAL NUCLEAR EXPLOSION FRACTURING OF GEOLOGICAL FORMATIONS. Terhune, R. W. (To United States Atomic Energy Commission). U. S. Patent 3,712,374. 23 Jan 1973. Filed date 10 Mar 1971. 20p.

A vertically-spaced series of nuclear explosive devices is emplaced in a subterranean formation and the lowermost explosive is detonated first to provide a nuclear chimney having an apical void spaced therein. The next higher device is then detonated to cause a generally cylindrical plug region to be displaced downwardly partially into said void space while creating a nuclear chimney similar to the first and the procedure is repeated with successively higher of the emplaced devices. A fractured shear of fault zone surrounds the cylindrical plug while an extensive pattern of radial fractures is created thereabout as well as about the shot cavity and associated chimney. More economical and effective results can be obtained as required, e.g., in stimulating production from petroliferous formations. (3 claims, 25 figures) (Official Gazette)

**22448** NON COLLAPSE STEMMING OF CASING SUBJECTED TO EXPLOSIVE EFFECTS. Heckman, R. A. (to United States Atomic Energy Commission). U. S. Patent 3,707,188. 26 Dec 1972. Filed date 27 Apr 1971. 10p.

Tubular casing is installed along a formation interval through which open communication is to be preserved or established in proximity to an explosive device, particularly, a nuclear explosive. The casing is then filled, i.e., is stemmed with a fluidic agent having dilatant properties. When subjected to the severe stresses produced by detonation of the explosive the dilatant agent is transitorally transformed into a rigid incompressible form which prevents buckling and crushing of the casing. Upon diminution of the stress the agent returns to a fluidic form which may drain or otherwise depart from the casing providing open communication therethrough. (Official Gazette)

**22449** GEOMORPHIC EVIDENCE OF LATE HOLOCENE VERTICAL STABILITY IN THE ALEUTIAN ISLANDS, ALASKA. Morris, R. H.; Bucknam, R. C. (Geological Survey, Denver). Bull. Seismol. Soc. Amer.; 62: No. 6, 1365-1375(Dec 1972).

Reconnaissance studies of Holocene coastal geomorphic features of the Aleutian Islands and the western part of the Alaska Peninsula indicate that, despite the high seismicity of the Aleutian Arc, most of the Aleutian Ridge has been vertically stable since at least the time sea level reached about its present position 2,000 to 4,000 years ago. Lack of youthful raised marine terraces, the presence of prograded beach ridges at the same general level as the modern ridge, and the widespread occurrence of a horizontal intertidal platform as much as 400 m wide are the primary lines of evidence for vertical stability. Detection of vertical movement is restricted by the natural vertical range inherent in the various coastal features, but it is believed that uplift of more than the local tidal fluctuation ($\approx$2 m) would be recognizable. Clear-cut evidence of uplift of coastal features that are thought to date subsequent to the time when sea level reached about its present position has so far been recognized only in a few areas in the Aleutians, and the amount of uplift in those localities is generally only several meters. The evidence of vertical stability of the Aleutian Ridge in areas near the epicenters of earthquakes associated with destructive tsunamis indicates that large vertical displacements thought to produce tsunamis do not extend to the subaerial part of the ridge. A dislocation model for an underthrusting Pacific plate suggests to us that vertical displacements at the Aleutian Ridge may be only a small fraction of those in the vicinity of the Aleutian Terrace and Trench. (auth)

**22450** SEISMOLOGICAL ASPECTS OF THE CANNIKIN NUCLEAR EXPLOSION. Willis, D. E.; George, G. D.; Poetzl, K. G.; Saltzer, C. E.; Shakal, A. F.; Torfin, R. D.; Woodzick, T. L.; Wolosin, C. (Univ. of Wisconsin, Milwaukee). Bull. Seismol. Soc. Amer.; 62: No. 6, 1377-1395 (Dec 1972).

Predicted and postshot geological and geophysical factors associated with the large underground nuclear detonation CANNIKIN are presented. An average $m_b$ magnitude of 7.02 and an $M_s$ magnitude of 5.74 were determined from 56 stations of the WWSSN and Canadian seismograph networks. No change was detected in the naturally occurring pattern of earthquakes recorded at regional and teleseismic distances to indicate that the shot affected natural seismicity other than at close distances. A complex group of waves with mixed Love- and Rayleigh-type motion was observed in latter parts of the surface-wave train recorded at stations across Canada and the United States, which could possibly be associated with an earthquake occurring several minutes after the shot. Surface-wave magnitudes computed for the Love-type motion were smaller than the magnitudes computed from maximum surface-wave amplitudes. (auth)

**22451** ESTIMATED EARTHQUAKE PROBABILITIES IN THE NORTH CIRCUM-PACIFIC AREA. Shakal, A. F.; Willis, D. E. (Univ. of Wisconsin, Milwaukee). Bull. Seismol. Soc. Amer.; 62: No. 6, 1397-1410(Dec 1972).

Gumbel's extreme value theory is applied to the estimation of probabilities of occurrence and return periods for large earthquakes in the north circum-Pacific area, using earthquake data from 1930 through 1971. The probability model of Epstein and Lomnitz is discussed with reference to Gumbel's extreme value theory. Estimated probabilities and expected extremes within individual tectonic blocks are calculated and compared. The area of the Aleutian Arc between 155°W and 167°W is found to have about an 80 per cent probability of an $M_s \geq 8$ earthquake by 1980. (auth)

**22452** SEISMIC EFFECTS OF THE MILROW AND CANNIKIN NUCLEAR EXPLOSION. Engdahl, E. R. (National Oceanic and Atmospheric Administration, Boulder, CO). Bull. Seismol. Soc. Amer.; 62: No. 6, 1411-1423(Dec 1972).

Seismic effects of the underground nuclear explosions MILROW (October 1969, about 1 megaton) and CANNIKIN (November 1971, under 5 megatons) were monitored by a network of continuously recording, high-frequency, high-gain seismographs located on Amchitka and nearby islands. Each explosion was immediately followed by hundreds of small, discrete events ($m_B < 4$), of similar focal mechanism and with a characteristic low-frequency signature, which were apparently related to the deterioration of the explosion cavity. This activity intensified, then terminated within minutes of a large, complex multiple event and concurrent formation of a surface subsided area that signaled complete collapse of the explosion cavity (MILROW, 37 hr; CANNIKIN, 38 hr). A number of small explosion-stimulated tectonic events, apparently unrelated to the collapse phenomenon, occurred intermittently for several weeks following each explosion—near the explosion cavity and up to 13 km southeast of CANNIKIN ground zero along the Island. These events were confined to the upper crust of the Island, had characteristic high-frequency signatures, and, near the Rifle Range Fault, had focal mechanisms which could be correlated with pre-existing faulting. The evidence points to a short-term interaction of the explosions with local ambient tectonic stresses. Because these stresses are of relatively low level on Amchitka, the observed seismic effects were significantly less extensive and smaller than similar effects reported from high-yield explosions at the Nevada Test Site. Continuous monitoring of the natural seismicity of the Amchitka region since 1968 has not revealed other evidence for an interaction between either MILROW or CANNIKIN and natural tectonic processes. The structural stability and apparent low level of stress in the upper crust of Amchitka suggest that the Island effectively is seismically decoupled from the active subduction zone below. (auth)

**22453** TECTONIC STRAIN-RELEASE CHARACTERISTICS OF CANNIKIN. Toksoez, M. N.; Kehrer, H. H. (Massachusetts Inst. of Tech., Cambridge). Bull. Seismol. Soc. Amer.; 62: No. 6, 1425-1438(Dec 1972).

The tectonic strain-release characteristics of the CANNIKIN nuclear explosion are determined from seismic surface waves and static strain changes associated with the event. The source is considered to be the superposition of an isotropic explosion component and a tectonic component consisting of a fault of arbitrary orientation. From Love-to-Rayleigh-wave amplitude ratios, the strength of the tectonic component (F) relative to the explosion is determined to be 0.6. The parameters of the fault are found to be consistent with nearby faults and displacements observed following the event. Reasonable agreement with observed static strains is also obtained with a fault 20 km long, but of different orientation. Discrepancies between observed and theoretical strains indicate the complexity of strain readjustment. The relatively small amount of tectonic strain release associated with CANNIKIN is probably due either to the low rigidity of the medium or to low ambient stresses near the surface. (auth)

**22454** UPPER MANTLE BENEATH THE ALEUTIAN ISLAND ARC FROM PURE-PATH RAYLEIGH-WAVE DISPERSION DATA. Jacob, K. H.; Hamada, K. (Columbia Univ., Palisades, NY). Bull. Seismol. Soc. Amer.; 62: No. 6, 1439-1453(Dec 1972).

Group velocities of Rayleigh waves recorded at a long-period seismograph station on Amchitka Island were obtained for mixed tectonic paths across the Pacific and the Aleutian Island Arc Ridge. The mixed-path group velocities for periods between 20 and 60 were then separated into pure-oceanic and pure-ridge path group velocities. The group velocities for the pure paths along the Aleutian ridge are on the average 0.36 km/s lower than those for the purely oceanic paths across the Pacific. Inversion of the pure-ridge group velocities yields almost continental shear velocities in the crust, a very gradual crust-mantle transition at depths between 20 and 40 km, a thin lithospheric lid of uppermost mantle material between 30 and 70 km with relatively low maximum shear velocities approaching 4.4 km/s, and a very pronounced low-velocity zone at depths below 70 km with an average shear velocity of 4.1 km/s. The computed shear velocity structure beneath the Aleutian Ridge is compared to models for other tectonically active and stable regions. (auth)

**22455** SECULAR STRAIN MEASUREMENTS BEFORE AND AFTER THE CANNIKIN NUCLEAR TEST. Butler, D.; Brown, P. L. (Colorado School of Mines, Golden). Bull. Seismol. Soc. Amer.; 62: No. 6, 1455-1456(Dec 1972).

Secular earth-strain measurements were made in the central Aleutian Islands during the years 1970 and 1971. An annual variation of about $3 \times 10^{-6}$ is evident on all records. A residual deformation of less than $3 \times 10^{-6}$ per year is detected on most records. The state of strain near Amchitka Island, Alaska, at the time of CANNIKIN, November 6, 1971, differed from the state of strain at the time of the MILROW test, October 2, 1969, by less than $1 \times 10^{-5}$. The strain records also contain novel episodes of large size (1 to $3 \times 10^{-6}$) and high strain rate ($1 \times 10^{-7}$/hr). (auth)

**22456** STRAIN AND TILT RECORDS OF THE CANNIKIN NUCLEAR TEST. Romig, P. R.; Tocher, D.; Butler, D.; Wideman, C. J. (Colorado School of Mines, Golden). Bull. Seismol. Soc. Amer.; 62: No. 6, 1459-1471(Dec 1972).

During the CANNIKIN underground nuclear test of November 6, 1971, near-surface earth deformations were observed by a total of 26 strainmeters and eight tiltmeters at nine sites in the Aleutian Islands at distances of 10 to 1125 km from ground zero on Amchitka Island. Permanent strain steps were observed at all stations. The size of strain steps observed at about 10 km ($<10^{-4}$) implies that the zone of nonelastic behavior extended to more than 10 km from ground zero. The size of strain steps observed at 295 and 1125 km ($<10^{-6}$) indicates that the residual strains at these distances were not as large as the amplitude of the daily earth tide. The permanent steps exhibit a pronounced directional asymmetry but, at five stations, are in reasonable agreement with predictions based on the work of Wideman and Major (1967). Redundant observations of areal strains at two stations yield values of $-29.5 \times 10^{-9}$ versus $-24.2 \times 10^{-9}$ and $-2.1 \times 10^{-7}$ versus $-3.2 \times 10^{-7}$. (auth)

**22457** INTERPRETATION OF STRAIN DATA: CANNIKIN NUCLEAR TEST. Romig, P. R. (Colorado School of Mines, Golden). Bull. Seismol. Soc. Amer.; 62: No. 6, 1473-1478(Dec 1972).

Immediately following CANNIKIN, strain and tilt steps were recorded at distances of 10 to 1,100 km. At the 10-km stations, the steps ($>10^{-4}$) were larger than expected and indicated that nonelastic effects existed out to that distance. The "quasi-static" strain step, which may represent elastic response to pressure in the cavity, had two exponential decay constants: 10.6 min during the first 5 min and 17.7 min after 8-min postshot. A significant asymmetry in the strain field, evident from observatories at distances of 15 to 300 km, suggests faulting near ground zero. The fault movement was equivalent to that normally associated with an earthquake of magnitude 6 to 6½, which implies a fault length of 10 to 30 km and a dislocation of 30 to 100 cm. The steps recorded at the time of collapse are compatible with a collapse mechanism, thus suggesting that little if any fault movement occurred away from the chimney at that time. (auth)

**22458** QUASI-STATIC MAGNETIC FIELD CHANGES ASSOCIATED WITH THE CANNIKIN NUCLEAR EXPLOSION. Hasbrouck, W. P.; Allen, J. H. (National Oceanic and Atmospheric Administration, Boulder, CO). Bull. Seismol. Soc. Amer.; 62: No. 6, 1479-1487(Dec 1972).

As a result of the CANNIKIN nuclear explosion, the magnetic field several kilometers from the epicenter appears to have been permanently altered. Within 30 s after detonation, a proton magnetometer 3 km away recorded a 9-gamma step increase in total magnetic field. Continuous difference recordings between the station at a distance of 3 km from the epicenter and one at 9 km showed that a 7.0-gamma average increase was maintained between these locations for 8 d after the shot. Along a ½-km traverse centered across a portion of a fault 1.6 km from ground zero, postshot-minus-preshot magnetic field difference readings decreased semi-sinusoidally from a high value of +13 gammas in the shot-contained block to a low value of −11 gammas in the distal block. Within 15 m to either side of the fault trace, a 15-gamma wedge-shaped magnetic low was observed. The magnetic effects can be reasonably interpreted as being caused by either shot-produced residual stresses or shot-caused alterations of remanent magnetization. (auth)

**22459** CLOSE-IN GROUND MOTION FROM THE MILROW AND CANNIKIN EVENTS. Perret, W. R. (Sandia Labs, Albuquerque, NM). Bull. Seismol. Soc. Amer.; 62: No. 6, 1489-1504 (Dec 1972).

Motion of the ground induced by the CANNIKIN and MILROW nuclear explosions beneath Amchitka Island was observed at vertical arrays of subsurface stations in borings offset 90 m from the shot holes and at surface stations at distances ranging from surface zero to about 10 km. Acceleration, particle velocity, and displacement time histories were obtained: vertical components only in the vertical arrays and three orthogonal components at surface stations. MILROW results indicate Rayleigh waves in records from a horizontal range of one-half shot depth and beyond. Analysis showed the initial spall depth near 110 m, with later spallation below 150 m and between 30 and 90 m. Surface data indicate spallation extended laterally to four times shot depth. CANNIKIN data were truncated at about 1.8 s by power circuit malfunction. Peak motion was recorded at all but the most remote CANNIKIN station before loss of power. Comparison of CANNIKIN data with those from MILROW indicate greater peak motions from the more energetic CANNIKIN explosion, but scaled peak motion from these events are similar. (auth)

**22460** PRELIMINARY RESULTS OF GROUND DEFORMATION MEASUREMENTS NEAR THE CANNIKIN EXPLOSION. Dickey, D. D.; McKeown, F. A.; Bucknam, R. C. (Geological Survey, Denver). Bull. Seismol. Soc. Amer.; 62: No. 6, 1505-1518(Dec 1972).

Ground deformation around the CANNIKIN underground nuclear explosion was studied by means of geodetic measurements, observation of tilt in lakes, and analysis of high-speed motion pictures. The lengths of 53 lines of the order of 1 km long located as many as 7 km from ground zero (GZ) were measured before and after the explosion. Principal strains calculated from the observed changes in length indicate northeast-oriented extension, which is interpreted as reflecting, in part, the release of tectonic strain. Information from an incomplete remeasurement of level lines indicates as much as about 1 m of residual uplift along nearly 2 km of the Bering coast adjacent to the explosion site. Measurements of tilt at six lakes differ in magnitude and direction from the values expected to be produced by expansion of the explosion cavity, but seem to be related to the influence of geological structures near the lakes. High-speed motion pictures indicate that the ground surface in the GZ area had risen vertically about 8 m by 1.4 s after the explosion and had returned to within about 1 m of its original elevation by 4 s after the explosion. (auth)

**22461** VISIBLE GEOLOGICAL EFFECTS OF THE CANNIKIN EVENT. Morris, R. H.; Gard, L. M.; Snyder, R. P. (Geological Survey, Denver). Bull. Seismol. Soc. Amer.; 62: No. 6, 1519-1526(Dec 1972).

Postshot field investigations indicate that most of the visible geological effects produced by the CANNIKIN event are limited to an area of a 2-km radius from ground zero (GZ). Two stages of fracturing are recognized, one at shot time that induced a maximum of 0.6 m vertical displacement along the Teal Creek Fault located 1,070 m northwest of GZ, and one inferred to have occurred at collapse time (38 h later). The three principal directions of fractures are east-northeast, northwest, and north and are related to pre-existing faults and lineaments. Major displacement along a fault located 760 m southeast of GZ is inferred to have occurred during collapse. Preliminary surveys indicate that the collapse sink is asymmetric with relation to GZ. The oval subsidence area is 1,270 by 915 m and the surface low, located 366 m southeast of GZ, subsided about 20 m. Several lakes are forming in the sink area. A portion of the intertidal platform along the Bering coast was uplifted about 1 m and major rock slides occurred along the cliffs within this zone of uplift. Elsewhere, minor rockfalls, slides and tundra slumps occurred along cliffs or steep slopes. Lake beds have been fractured and, in some cases, the lakes have drained. (auth)

**22462** HYDROLOGICAL EFFECTS OF THE CANNIKIN EVENT. Gonzalez, D. D.; Wollitz, L. E. (Geological Survey, Denver). Bull. Seismol. Soc. Amer.; 62: No. 6, 1527-1542 (Dec 1972).

The hydrological effects of the underground nuclear explosion, CANNIKIN, were monitored by a network of streamflow stations and ground-water boreholes located on Amchitka Island. Continuous records were obtained from six surface-water stations that range from 1.50 to 14.07 km from surface ground zero (SGZ). Confined fluid pressures in boreholes were recorded at five stations with slant distances ranging from 2.14 to 14.11 km from ground zero (GZ). Fluctuations of water level were measured in one open hole 6.42 km from GZ. The stream system draining the CANNIKIN site lost 96% of its flow within hours after the explosion. Lakes formed near SGZ remain low in stage and appear to be providing infill water for the rubble chimney. Measurements in boreholes also showed that the groundwater gradient was toward the explosion site. The response of confined fluid pressures was recorded in a number of boreholes, and a relationship between maximum fluid pressure, P, and slant range, $R_s$, has been established as $P = 920 R_s^{-2.10}$. (auth)

**22463** REACTION OF SHALLOW ONSHORE WATER TO GROUND SHOCK. Merritt, M. L. (Sandia Labs., Albuquerque, NM). Bull. Seismol. Soc. Amer.; 62: No. 6, 1543-1557(Dec 1972).

Pressures and accelerations were measured in and near numerous ponds and lakes in Amchitka during the nuclear shot CANNIKIN, using peak measuring and full time-history recording instruments. The resulting pressures and accelerations were similar in wave shape: each showed an initial pulse, a period of free fall during spall, and an impact shock. It is found that when reverberation times in the water are short compared to rise times and other characteristic times of the ground shock, the water responds as a whole, and the pressure in it is proportional to the acceleration. When reverberation times are longer than rise times, pressure overshoots and oscillates about the simple proportionality. (auth)

**22464** LONG-PERIOD WATER-WAVE MEASUREMENTS FOR THE MILROW AND CANNIKIN NUCLEAR EXPLOSIONS. Olsen, K. H.; Stewart, J. N.; McNeil, J. E.; Vitousek, M. J. (Los Alamos Scientific Lab., NM). Bull. Seismol. Soc. Amer.; 62: No. 6, 1559-1578(Dec 1972).

Three types of high-resolution, ocean-bottom instruments were installed to monitor predicted low-amplitude, long-period water-wave activity associated with the MILROW and CANNIKIN underground nuclear explosions at Amchitka Island, Alaska. These instruments provided data on: permanent vertical ocean-floor displacements in the expected generation region up to 15 km from surface zero; wave propagation in deep water at ranges beyond 15 km; and shoaling and nearshore effects at Amchitka and several other islands in the Aleutian chain. For MILROW, permanent undersea displacements and propagating waves were unobservable above the natural long-period background level of ~1 cm (rms). For CANNIKIN, areas of ocean-floor uplift were observed in both the Bering Sea and in the Pacific Ocean within 6 km of ground zero. Vertical displacements averaged several centimeters, with a more localized region showing 56 cm of uplift; these values seem to be consistent with results of land surveys on the island. Resonant oscillations having amplitudes up to 10 cm were induced in two bays on the Bering Sea coastline. The absence of observable tsunami-like waves at deep water instruments and at more distant islands suggests that much of the water-wave energy generated near CANNIKIN was constrained in edge-wave modes along the shallow offshore slope along the Bering Sea coastline of Amchitka, and was dissipated there. (auth)

**22465** TSUNAMI MODEL: GENERATION AND OPEN-SEA CHARACTERISTICS. Hwang, L. S.; Butler, H. L.; Divoky, D. J. (Tetra Tech., Inc., Pasadena, CA). Bull. Seismol. Soc. Amer.; 62: No. 6, 1579-1596(Dec 1972).

A numerical model of the generation and transoceanic propagation of tsunamis is developed. The model is based on hydrodynamic equations in a spherical coordinate system to account for the spherical nature of the Earth. The model provides a deterministic approach to the description of tsunami waves, and is verified by hindcasting the wave behavior following the Alaskan earthquake of 1964. Results of the computation are compared with field measurements (Wake Island deep-water gage records and results obtained from the numerical model developed previously by Hwang and Divoky, 1970). From these calculations, the excessive damage at Crescent City, California, seems to have resulted in part from the phenomenon of tsunami directionality. Finally, the model is applied to a hypothetical CANNIKIN source (Rat Islands source) and shows that the resulting tsunami energy radiation pattern would be highly directional with the largest wave heights passing through the west-central Pacific. (auth)

**22466** THEORETICAL AND OBSERVED DISTANCE CORRECTIONS FOR RAYLEIGH-WAVE MAGNITUDE. Alewine, R. W. III (California Inst. of Tech., Pasadena). Bull. Seismol. Soc. Amer.; 62: No. 6, 1611-1619(Dec 1972).

Examination of the distance correction factor used in the widely accepted formula for surface-wave magnitude reveals that this empirically derived linear formula fails to give an accurate approximation to the theoretical nonlinear amplitude-distance relation for epicentral distances less than 15°. For epicentral distances greater than 15°, the empirical formula contains an implied oceanic-type energy-dissipation coefficient. When the original Gutenberg theoretical surface-wave magnitude formula with an appropriate continental energy-dissipation coefficient is applied to explosion data from the Nevada Test Site, a consistent surface-wave magnitude is obtained at all distances. A systematic method of normalizing Rayleigh-wave magnitudes obtained over different types of propagation paths is suggested. This normalization might provide a means for better separating natural events and explosions in the $m_b - M_s$ plots. (auth)

**22467** PROPAGATION OF UNDERGROUND EXPLOSION WAVES IN THE NEARLY ELASTIC RANGE. Andrews, D. J.; Shlien, S. (Massachusetts Inst. of Tech., Cambridge). Bull. Seismol. Soc. Amer.; 62: No. 6, 1691-1698(Dec 1972).

The effect of small anelasticity on the propagation of spherically symmetric waves is examined with numerical calculations. The type of anelasticity used is static hysteresis with nominal Q value of 100. Linear theories do not apply in this case. Fourier components of different frequencies do not propagate independently, but energy is transferred to lower frequencies. The extent to which reduced displacement potential is not invariant with respect to radius is examined for explosions in granite, salt, and shale. (auth)

**22468** MONITORING UNDERGROUND EXPLOSIONS. Davies, D. (Massachusetts Inst. of Tech., Lexington). Nature (London); 241: No. 5384, 19-24(5 Jan 1973).

Seismological means for detecting and identifying underground nuclear explosions have improved steadily during the past ten years. A technique now exists for separating explosions from earthquakes. The problem is lowering the threshold and understanding the occasional problematic event. (auth)

## Protective Structures and Equipment

**22469** (ARH-1761) METHOD FOR SEALED PERSONNEL PASSAGE THROUGH A SEALED BARRIER. Moulthrop, H. A. (Atlantic Richfield Hanford Co., Richland, Wash.). 30 Jul 1971. Contract AT(45-1)-2130. 78p. Dep. NTIS $6.00.

A concept and method was developed and demonstrated for permitting persons to pass through a sealed contamination barrier into a contaminated enclosure, and to return. The method permits this transbarrier passage to be repeated any number of times in a practical and routine manner. At no time during the entrance or the exit is there an opening through the sealed contaminated barrier. This method, as conceived and demonstrated, is applied not only to the person making the transbarrier passage in a sealed suit, but also to all of the service lines which are disconnected and reconnected between each personnel entrance. The concept and demonstrated method provides for keeping all service gear and service lines in a free-from-contamination condition at all times. This lack of contamination permits immediate reuse at the completion of any job entry. Provision is also included for the quick and contamination-free rescue from the enclosure of any person who may become suddenly incapacitated while within the contaminated enclosure. The method has been demonstrated to be very practical and as fast and efficient as traditional entry and exit techniques. Cost is also reduced by avoiding need for replacing valuable gear such as cooling and communication equipment. These are worn under the sealed suits in all cases. (auth)

**22470** (MLM-2008) DEVELOPMENT OF THE MOUND LABORATORY SUPPLIED-AIR BUBBLE SUIT. Phillabaum, G. L.; Adams, P. C. (Mound Lab., Miamisburg, Ohio). 26 Feb 1973. Contract AT(33-1)-Gen-53. 46p. Dep. NTIS.

A supplied-air bubble suit was developed to improve the protection of personnel working with radioactive materials and other contaminants. Details are given of the development work, design specifications, and procedures for proper usage of the bubble suit. The bubble suit was developed for use in operations where the airborne contamination level of certain radionuclides exceeds Radioactive Concentration Guides. The bubble suit has a number of applications in providing protection against radioactive or nonradioactive materials. At Mound Laboratory, the bubble suit has been used over an extensive period in the termination of a plutonium-238 facility. During this period highly satisfactory results were achieved in personnel protection. (auth)

**22471** EASILY MANIPULABLE GLOVE BOX. Blum, J. (to Ugine Kuhlmann). French Patent 1,603,109. 30 Apr 1971. Filed date 25 Jun 1968. 5p. (In French).

A flexible at least partially transparent sheet of material is used to construct the glove box, which is provided with holes for the gloves and at least one tubular opening. The glove box can be set up where it is required, e.g., to replace an element of a duct containing a dangerous gas or for preparing an element of a pipe contaminated with radioactive substances. (FR)

**22472** LABORATORY FOR ACTIVATION ANALYSES USING NEUTROSTOP. Zitnansky, B. (Research Inst. for Welding, Bratislava). Jad. Energ.; 19: No. 2, 51-54(Feb 1973). (In Slovak).

The performance of NEUTROSTOP bricks for shielding a 14-MeV neutron generator used in activation analysis is discussed. Dose measurements showed that very good biological protection was achieved with the relatively light material. (TFD)

**22473** PROTECTIVE EQUIPMENT FOR PERSONNEL WORKING IN CONTAMINATED ENVIRONMENTS. Savornin, J. (To Commissariat a l'Energie Atomique). French Patent 2,112,034. 16 Jun 1972. Filed date 24 Jul 1970. 7p. (In French).

Radioprotective equipment for personnel working in a tritiated environment is described. This equipment includes a protective suit made of a vinyl material provided with a means for its ventilation. This ventilation is accomplished with a single tube which serves for the air inlet into the suit and the subsequent extraction of the expired air (using an aspirator). The back of the suit is provided with a zip closing a slit which extends from one elbow to the other. The equipment is also provided with seams of vinyl material welded to the suit which extend along the entire length of the slit and/or each joint, this seam being of such a size as to enable it to be partially covered. These seams are welded together to form leaktight joints. (FR)

## Safety Engineering

*Refer also to abstract 22652.*

**22474** IONIZING RADIATION PROTECTION IN MECHANICAL ENGINEERING MINISTRY ESTABLISHMENTS. Lapusan, A.; Stanescu, I.; Todea, G. Constr. Masini; 23: No. 9, 560-566 (Sep 1971). (In Rumanian).

A review of the effects of ionizing radiation on the body and of safety measures is followed by a procedure for calculating radiation shielding. Advice is given on the safe use of penetrating radiation in mechanical engineering: observance of regulations on the design and layout of x and $\gamma$ nondestructive testing laboratories; precise calculation of all ionizing radiation sources and periodic dosimetry inside and outside laboratories; installation of alarm systems; strict observation of safe working practices. (Occup. Saf. Health Abstr.)

# ENVIRONMENTAL AND EARTH SCIENCES

**22475** (NLCO-1097) FMPC POLLUTION CONTROLS. Pennak, A. F. (National Lead Co. of Ohio, Cincinnati). 11 Dec 1972. Contract AT(30-1)-1156. 17p. (CONF-721211-1). Dep. NTIS.

From EPA air pollution control technology training session meeting; Cincinnati, Ohio, USA (14 Dec 1972).

Methods used for the control of emissions to the environment at the USAEC Feed Materials Production Center, Fernald, Ohio, are described. All residues containing uranium metals are recovered for their economic value. Pollutants include dusts produced during the processing of $MgF_2$ slag and other operations, sulfur oxides produced during the combustion of coal, and nitrogen oxides (NO and $NO_2$) produced during the use of $HNO_3$ in chemical processes. (CH)

## Minerals and Ores

*Refer also to abstracts 22162 and 22534.*

**22476** PARTITION OF URANIUM BETWEEN PERIDOTITE NODULES AND HOST BASALT. Nishimura, S. (Kyoto Univ.). Chem. Geol.; 10: No. 3, 211-221(Nov 1972).

Contents of uranium in mineral fractions from some basic rocks and peridotite nodules were measured. It appears that peridotite nodules range in uranium content, between $4.8 \times 10^{-2}$ to $8.2 \times 10^{-3}$ ppM. Uranium content in olivines ranges between $4.8 \times 10^{-2}$ to $1.2 \times 10^{-3}$ ppM. These values reflect the chemical fractionation occurring in magnetic processes. (auth)

## Radioactive Effluents

*Refer also to abstracts 22692, 22719, 23950, 23996, 24049, and 24204.*

**22477** (CONF-710847-, pp 125-130) SOME VIEWS ON THE LIMITATION OF RELEASES OF RADIOACTIVE MATERIAL FROM NUCLEAR POWER STATIONS. Hedgran, A. (Delegationen foer Atomenergifragor, Stockholm); Lindell, B. 1971. (In Swedish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

The limitation of the amount of radioactive material that may be released from a nuclear power plant is based on assessments of the resulting doses to the critical group of individuals and to the whole population. In addition, the ICRP recommendation that "all doses be kept as low as is readily achievable..." must be interpreted in terms of releases. The use of the concepts, dose commitment and PQR-cost, is discussed in relation to the release limitations. It is suggested that the population dose from a nuclear power plant should not exceed 1 manrem per MWyear(el) for the whole power cycle. Environmental monitoring will not suffice in the control of such low exposures; in addition to direct control of the release, radioecological research programs must be initiated to check the basic assumptions on the relationships between radiation doses and released activities. (auth)

**22478** (CONF-710847-, pp 265-268) INTRODUCTORY REMARKS TO THE NUCLEAR POWER PLANTS PANEL. Jensen, Henning. 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

Environmental protection policies and safety engineering practices, as they relate to nuclear power plants, are briefly discussed. (ERB)

**22479** (CONF-710847-, pp 269-273) INTRODUCTORY REMARKS TO THE NUCLEAR POWER PLANTS PANEL. Pollution from Nuclear Power Plants in Relation to General Environmental Pollution. Steensberg, Jens (National Health Service of Denmark, Copenhagen). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

The Danish temporary pollution control board, the use of isotopes in hygiene, siting of plants, environmental monitoring, and the problems of establishing norms and guidelines are briefly discussed. (ERB)

**22480** (Y-1866) EVALUATION OF SEVERAL METHODS OF DETECTING URANIUM PARTICULATES IN A DISPOSAL STACK AT THE OAK RIDGE Y-12 PLANT. Gallman, R. A. (Oak Ridge Y-12 Plant, Tenn. (USA)). 26 Feb 1973. Contract W-7405-eng-26. 20p. Dep. NTIS.

Four methods of monitoring the radioactivity from highly enriched uranium were evaluated as to their suitability for determining whether any significant amount of enriched material escapes into the air through an effluent stack at the Oak Ridge Y-12 Plant. Experimental work showed that two methods, alpha energy discrimination and x-ray energy analysis, can perform the measurement as required while maintaining a simplicity of operation and at a reasonable cost. Significant improvements can be made in both methods, but not without increasing the complexity of operation as well as the cost. (auth)

## Radioactivity Monitoring and Transport

*Refer also to abstracts 22392–22394, 24040, and 24093.*

**22481** (AAEC/E-246) ENVIRONMENTAL SURVEY AT THE A.A.E.C. RESEARCH ESTABLISHMENT, LUCAS HEIGHTS, RESULTS FOR THE PERIOD JANUARY–JULY 1970. Conway, N. F.; Dudaitis, A. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Nov 1972. 30p. Dep. NTIS (U. S. Sales Only) $3.50.

During the period January to July 1970 no radioactivity attributable to aerial dispersion from the Research Establishment was detected in the environment. In the Woronora estuary a number of radioisotopes other than those that occur naturally or in fallout, or in quantities in excess of natural or fallout concentrations were detected. These are attributed to low-level liquid effluent discharges in the estuary. Those found were tritium (as water), cobalt-60 (in fish, zostera and bottom sand from the discharge point), strontium-90 (in fish and bottom sand from the discharge point), cesium-137 (in bottom sand from the discharge point) zinc-65 (in oysters), and traces of excess thorium-232 daughters and excess gross alpha and beta activity (in bottom sand at the discharge point). These radioisotopes, with the exception of zinc-65, were also found in selected soil and vegetation samples taken along the liquid effluent pipe-line. At the solid waste burial ground, cobalt-60, attributed to buried waste, was detected in vegetation taken near the buried material and in the borehole nearest to the buried material. Levels of activity attributable to Research Establishment operations were similar to those of previous years and generally of the order of, or less than, one thousandth of the appropriately derived maximum permissible concentrations. Estimates of possible doses to individual members of the public from Research Establishment operations give results less than those due to weapons test fallout and much less than natural radiation background. (auth)

**22482** (CONF-710847-, pp 203-214) IN SITU GAMMA SPECTROSCOPY AS A METHOD FOR ENVIRONMENTAL SURVEILLANCE. Kahlos, H.; Blomqvist, L. (Inst. of Radiation Physics, Helsinki). 1971. (In Swedish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

An in situ measurement of the gamma energy spectrum above the ground surface makes it possible to identify the cause of variations in the exposure rate. Such measurements can be used to evaluate and control the gamma exposure from natural radioactivity in the soil, nuclear fallout, and the release of radionuclides from a nuclear installation. The method was applied in practice in field measurements in the vicinity of the nuclear power plant under construction in Lovisa. Gamma energy spectra were measured with a 3″ × 3″ NaI(Tl) detector and a portable multichannel analyzer. The method of measurement, calibration, and evaluation of the results are described. A comparison with other surveillance methods is also given. (auth)

**22483** (ORP/SID-72-5) $^{129}$I IN THE ENVIRONMENT AROUND A NUCLEAR FUEL REPROCESSING PLANT. Magno, P. J.; Reavey, T. C.; Apidianakis, J. C. (Office of Radiation Programs, Washington, D. C. (USA). Field Operations Div.). Oct 1972. 31p.

The specific activity of iodine-129, i.e., the ratio of the activity of iodine-129 to the weight of stable iodine, was measured in the environment around the Nuclear Fuel Services' reprocessing plant, West Valley, N. Y., during the summer of 1971. These measurements showed that the discharges of iodine-129 from Nuclear Fuel Services produced specific activities as high as 0.62 $\mu$Ci/g of iodine in the aqueous environment and 0.28 $\mu$Ci/g of iodine in the terrestrial environment around the plant. These values are about $10^4$ times greater than background levels. The average specific activity of iodine-129 in the environment around the plant was 0.1$\mu$Ci/g of iodine or 7 percent of the specific activity which if present in the human thyroid would result in the individual dose limit specified by the Federal Radiation Council. The results of this study indicated a need for control of iodine-129 discharges from nuclear fuel reprocessing plants and surveillance programs to evaluate the environmental buildup of this radionuclide. Analytical procedures for determination of iodine-129 by neutron activation analysis and by liquid scintillation counting are included. (auth)

**22484** QUALITY ASSURANCE IN ENVIRONMENTAL REPORTS. Beer, L. P.; Johnson, B. G. (Industrial Bio-Test Labs., Inc., Northbrook, IL). Power Eng.; 77: No. 2, 45–47(Feb 1973).

Environmental studies for utility installations that will require adequate quality assurance include: siting studies, predictive programs, preoperational monitoring, and operational monitoring. Examples of quality assurance programs are given for aquatic biology studies and radiological monitoring. (MCG)

## *Atmosphere*

*Refer also to abstracts 22778 and 22799.*

**22485** (AEC-tr-7417) SOURCES OF TRITIUM AND ITS RADIATION-HYGIENIC PROBLEMS. Carach, J.; Cechvala, L. Translated from Prac. Lek.; 23: No. 4, 120-125(1971). 16p. Dep. NTIS $3.00.

The biggest source of tritium in nature is the bombardment of atmospheric nitrogen ($^{14}$N) with secondary neutrons. All other sources contribute only to an insignificant amount to create the overall amount of natural tritium. Significant amounts of tritium are formed during explosion of thermonuclear weapons. The estimate is that 0.7 kilograms of $^{3}$H is formed per megaton equivalent. A major source of artificial tritium in the environment is the operation of heavy-water or light-water reactors, as well as manufacturing establishments which process burned-out reactor fuel. In the case of a heavy-water reactor, the balanced concentration of about 10 Ci per liter of $D_2O$ is obtained after 10 years of operation. Escapes of heavy water usually reach the escape speed of 2 to 3 percent annually (several kilograms daily). The most important method that is recommended for protection of personnel against tritium in a working environment is isolation of the workplace by means of plastic tents and by using airtight plastic clothing with intake of fresh air. Monitoring of personnel who come in contact with tritium is based on the level of tritium in urine. Decontamination procedures for equipment are described for eliminating contamination by tritium. From the viewpoint of the control of the living environment in areas surrounding nuclear facilities, it is purposeful to study the content of tritium in fallout, the level of tritium in milk, and its concentration in waste waters and surface waters. (auth)

**22486** (AERE-R-7245) RADIOACTIVE FALLOUT IN AIR AND RAIN. RESULTS TO THE MIDDLE OF 1972. Cambray, R. S.; Fisher, E. M. R.; Peirson, D. H.; Parker, A. (Atomic Energy Research Establishment, Harwell (England)). Nov 1972. 56p. Dep. NTIS (U. S. Sales Only) $5.00. UK pounds 1.00.

Samples of atmospheric dust and rainwater were collected from the United Kingdom and elsewhere. Results are presented of analyses of these samples for various fallout fission products and certain other radionuclides. The average concentrations of the long-lived fission products in atmosphere and rain in the United Kingdom were, in the first six months of 1972, about half those for the first six months of 1971 and about one twentieth of the maximum which was reached in 1963/64. In the summer of 1962 the Chinese explosion of 14 October 1970 contributed about 35% and the Chinese explosion of 18 March 1972 about 10% of the long-lived activity. An estimate is made of the world-wide deposition of $^{137}$Cs and $^{90}$Sr in rain to the end of 1971: the cumulative deposit has remained substantially constant since 1966. In the southern hemisphere about 40% of the long-lived activity in air in mid-1972 was contributed by the French tests held in the South Pacific in 1971. The direct determination of $^{90}$Sr by radiochemical methods is now restricted to a single bulked rainwater sample from the stations in the United Kingdom for each quarter of the year. Individual quarterly samples are measured for $^{137}$Cs as before. Measurements of short-lived fission products in air and rain are given in an appendix. The gamma and beta dose rates from fallout at Chilton are estimated from the observed deposition. (auth)

**22487** (EUR–4907) RESULTS OF ENVIRONMENTAL RADIOACTIVITY MEASUREMENTS IN THE COMMUNITY COUNTRIES IN 1971. Air–Fallout–Water. (European Communities, Luxembourg. Commission). Dec 1972. 76p. (In Several Languages). Dep. NTIS (U. S. Sales Only). EUR FB 100,-.

This report contains the results of the measurements carried out in 1971 by the member States at the environmental radioactivity monitoring stations, together with certain data obtained at Euratom's Joint Research Center, Ispra. The report comprises an introductory note and three sections dealing with measurements of radioactivity in the air at ground level, in fallout, and in water. Most of these measurements relate to total beta radioactivity. The measurement results for $^{137}$Cs and $^{90}$Sr are also given, as well as the amount of precipitation observed at fallout sampling stations. Graphs are given to show the pattern followed throughout the year. A comparison is being drawn with the development over the years 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969 and 1970 as well as with the situation in 1971 in the United States and Canada. (auth)

**22488** (ORO–3944-5) ATMOSPHERIC HT AND HTO, 1968–71. Tritium Laboratory data report No. 2. Oestlund, H. G.; Mason, A. S.; Ydfalk, A. (Miami Univ., Fla. Rosenstiel School of Marine and Atmospheric Sciences). Dec 1972. Contract AT(40-1)-3944. 55p. Dep. NTIS $4.75.

Measurements of atmospheric HTO and HT during the time period 1968 to 1971 are presented in tabular and graphical form. The HTO measurements are on samples of vapor and of rains. A novel extraction method of HT from the air has made it possible to collect daily samples at various points on the globe. Aircraft sampling of HTO and HT in the vertical through the tropopause, and along a meridian from 30°N through 65°S was performed. The previous increase in atmospheric HT stopped at a level of about 45 atoms of T (as HT and $T_2$) per mg of air in the troposphere. The distribution pattern of HTO and HT indicated that the source for HTO is still in the stratosphere (thermonuclear bomb debris) but that the source of HT is at ground level. The HTO inventory of the troposphere decreased so that there is now more tritium as HT than as HTO in the troposphere. (auth)

**22489** (SCPRI(RM)-8-1972 and Suppl.) REPORT OF ACTIVITY, AUGUST 1972. 1972. 34p. (In French). Dep. NTIS (U. S. Sales Only).

Data are presented on the radioactivity in environmental samples collected at various locations in France during August 1972. (CH)

**22490** DATA. SECTION III. AIR AND DEPOSITION. Radiat. Data Rep.; 14: No. 1, 35-46(Jan 1973).

Data are presented on the gross $\beta$ radioactivity in samples of surface atmosphere and precipitation collected throughout the USA, Canada, Central America, and South America during September 1972. Data are included on the content of Pu in atmospheric particulates collected at various sites in the USA during April through June 1972. (CH)

## *Water*

**22491** (UCSC–34-P-163-X-4) MEASUREMENTS OF BOMB PRODUCED RADIOCARBON IN THE SURFACE AND SUBSURFACE WATER OF THE PACIFIC OCEAN. Interim progress report, March 1, 1969–February 28, 1970. Suess, H. E. 1 Mar 1970. Contract AT(11-1)-34. 8p. Dep. NTIS.

**22492** DATA. SECTION II. WATER. Radiat. Data Rep.; 14: No. 1, 27-34(Jan 1973).

Data are presented on the gross $\alpha$ and $\beta$ radioactivity in samples of surface waters collected during May 1972 from various locations throughout the USA. Data are also included on the content of tritium in samples of surface waters, drinking water, and precipitation collected at various locations during April through June 1972. (CH)

## *Ecosystems and Food Cycles*

*Refer also to abstracts 22791, 22801, 22806, 22814, and 22816.*

**22493** (CONF-710847-, pp 131-138) VIEWPOINTS ON "NON-ACTION LEVELS" FOR FOODSTUFFS IN CASE OF RADIOACTIVE CONTAMINATION. Swedjemark, G. A. (Statens Stralskyddsinstitut, Stockholm). 1971. (In Swedish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

On the basis of the PQR concept presented by Hedgran and Lindell in 1970, a "non-action level" can be derived on economical grounds. The PQR concept implies that the practice of radiation protection involves a certain reasonable cost of eliminating one manrad. The economically based non-action level means that the PQR value of rejecting the food in question is the same as the pure economical value of the food as such. It is of interest to investigate how far the contamination of the environment from nuclear tests has carried various food-stuffs towards such a limit for non-action. Hitherto the highest measured concentrations in most food-stuffs in Sweden have been less that 10% of the non-action levels based on the PQR concept. The exceptions are $^{131}$I in milk (40 to 200%) and $^{137}$Cs in reindeer meat (20%). It is also of interest to see what margins there have been between the existing concentrations of radioactive nuclides and action levels that would be implied by high immediate risks of acute injuries. For most food-stuffs the highest measured intake did not exceed 0.1% of such action levels. (auth)

**22494** (CONF-710847-, pp 275-284) MODELS FOR THE $^{137}$Cs- AND $^{90}$Sr-CONTAMINATION OF MILK IN FINLAND. Castren, O. I. (Inst. of Radiation Physics, Helsinki). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

Models were constructed from the 1960 to 1971 milk survey results using regression analysis. The dependent variables were the average levels for the periods June to September and October to May. Fallout of $^{137}$Cs and $^{90}$Sr during the same and three preceding years as well as the cumulative deposition up to the end of the fourth preceding year were used as independent variables. The models were linear, and the constant term was forced to be zero. Because the statistical spread of the coefficients in the five-term model was very large, independent variables were combined to attain a compromise between the accuracy of the model and the accuracy of the coefficients. From the ten models chosen for both summer and winter and each of the five sampling areas studied, models for the production-weighted annual country-wide means were constructed. The transfer coefficients from fallout to milk, calculated from the models chosen, agreed with those from the best five-term models. The transfer coefficients for the production-weighted country-wide means were: 15.8 (8.1 to 32.6) pCi y $(gK)^{-1}$ per mCi km$^{-2}$ for $^{137}$Cs and 3.8 (3.0 to 4.5) pCi y $(gCa)^{-1}$ per mCi km$^{-2}$ for $^{90}$Sr. The lowest and highest area values are given in parentheses. (auth)

**22495** (RT/PROT-(72)27) DIFFUSION OF RADIOACTIVE EFFLUENTS IN THE GULF OF TARANTO: DIRECT MEASURE OF CURRENT AND THEORETICAL CALCULATIONS. Benedetti, A.; Bernhard, M.; Bruschi, A.; Cagnetti, P.; Zattera, A. (Comitato Nazionale Per l'Energia Nucleare, Rome (Italy)). 14 Sep 1972. 32p. (In Italian). (CONF-701235-1). Dep. NTIS (U. S. Sales Only).

From twenty-second meeting of CIESM; Rome, Italy (Dec 1970).

A current meter consisting of a Savonius rotor, a rudder, and an electronic registration device is described. The data collected with the current meters are used to estimate the dilution rate of the radioactive waste substances from a reactor fuel element reprocessing plant that should be disposed through the pipeline by developing mathematical models. (auth)

**22496** (UCSD-34-P-163-X-3) MEASUREMENTS OF BOMB PRODUCED RADIOCARBON IN THE SURFACE SUBSURFACE WATER OF THE PACIFIC OCEAN. Interim Progress Report, June 1, 1968-February 28, 1969. Suess, H. E. (Scripps Institution of Oceanography, La Jolla, Calif.). 14 Mar 1969. Contract AT(11-1)-34. 9p. Dep. NTIS $3.00.

Data are presented on the content of fallout $^{14}$C in Pacific Ocean surface water samples collected from various locations during January through March 1966 and September 1968. The equipment used for the extraction of carbon dioxide from seawater on shipboard is described. (CH)

**22497** (UCSD-34-P-163-X-6) MEASUREMENTS OF BOMB PRODUCED RADIOCARBON IN THE SURFACES AND SUBSURFACE WATER OF THE PACIFIC OCEAN. Final Technical Report, 1968-1972. Suess, H. E. 1 Mar 1973. Contract AT(11-1)-34. 11p. Dep. NTIS $3.00.

Data are presented on the content of fallout $^{14}$C in Pacific Ocean surface water samples collected from various locations during 1968 through 1970. (CH)

**22498** DATA. SECTION I. MILK AND FOOD. Radiat. Data Rep.; 14: No. 1, 17-26(Jan 1973).

Data are presented on the content of $^{137}$Cs and $^{90}$Sr in samples of milk collected at various locations throughout the USA, Canada, Central America, and South America during September 1972. The data are compared with data for the previous 12-month period. (CH)

**22499** SELECTION OF A SITE FOR THE GROUND DISPOSAL OF RADIOACTIVE WASTES. II. Selection of a Ground Disposal Site of Radioactive Wastes by the Sensitivity Analysis. Inoue, Y.; Morisawa, S. (Kyoto Univ.). Nippon Genshiryoku Gakkaishi; 14: No. 12, 652-660(Dec 1972). (In Japanese).

A discussion is presented on the desirable conditions in Japan for the ground disposal sites of radioactive wastes and an approximate method of estimating the internal radiation dose to man. Sixteen out of 26 environmental factors and three ecological transport paths of radionuclides through which leaked radionuclides migrate (i.e. the path of drinking water, seafoods, and vegetables) are quantitatively examined by sensitivity analysis. The relationships existing between the internal dose to human populations and each environmental factor are shown in an accompanying table. The differences between the strict and approximate calculations of the internal radiation dose are also examined, and the approximation is shown to be quite valid, particularly for the rough estimation of the safety of a ground disposal site for radioactive wastes. (auth)

**22500** DEGREE OF $^{90}$Sr CONTAMINATION OF PASTURE FODDER IN 1965-1967. Firsakova, S. K.; Shirshov, V. A. Agrokhimiya; No. 11, 128-131(1971). (In Russian).

The calcium content and $^{90}$Sr contamination of pasture plants were determined during 1965 to 1967 and measurements were made of $^{90}$Sr in soil at different depths. The $^{90}$Sr/Ca ratio in pasture plants decreased following application of fertilizers. The $^{90}$Sr content of pasture fodder was 2.22, 3.19, and 2.54 $\mu$Ci/kg in 1965, 1966, and 1967, respectively. (HLW)

**22501** RESULTS OF MONITORING THE $^{90}$Sr AND $^{137}$Cs CONTENTS IN FOODS IN THE GDR DURING 1962-1970. Schulze Wollgast, U. (Staatliche Zentrale fuer Strahlenschutz, Berlin). Kernenergie; 15: No. 6, 202-205(Jun 1972). (In German).

Strontium-90 and $^{137}$Cs contaminations of food stuff are gradually diminishing. Maximum $^{90}$Sr contamination of the milk was observed in 1963. In whole-diet samples the maximum $^{90}$Sr concentrations were measured in 1963 and 1964. In 1970, the $^{90}$Sr intake was 4% and the $^{137}$Cs intake amounted to 1% of the corresponding maximum permissible yearly intake of activity, whereas in 1963/64 the $^{90}$Sr intake was nearly 10% of the maximum permissible yearly intake of activity. (auth)

## Site Surveys

*Refer also to abstracts 22041, 22449, 22484, 22499, 22771, 23019, 24005, 24011, 24057, and 24129.*

**22502** (CONF-710847-, pp 141-158) SURVEY OF DIETARY, WORKING AND LIVING HABITS AMONG THE POPULATION SURROUNDING THE ATOMIC POWER STATION IN LOVISA. Salo, Anneli (Inst. of Radiation Physics, Helsinki). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

A survey of the dietary habits among the population living within a radius of 40 km from the reactor site in Lovisa was carried out by the interview method. Among the population living nearer than 5 km from the site, either permanently or as summer visitors, the dietary habits as well as the working and living habits were investigated. The method of survey and the material studied are described. Some preliminary results of the surveys are given as examples. (auth)

## Thermal Effluents

**22503** (ANL/ES-16) PHYSICAL MEASUREMENTS OF THERMAL DISCHARGES INTO LAKE MICHIGAN, 1971. Frigo, A. A.; Frye, D. E. (Argonne National Lab., Ill.). Oct 1972. Contract W-31-109-eng-38. 168p. Dep. NTIS $7.60.

A compilation of field data collected on Lake Michigan during the 1971 field year by Argonne National Laboratory under the auspices of the Great Lakes Research Program is presented. The data were collected for the purpose of studying the physical structure of thermal plumes existing at power-plant outfalls.

The power plants studied included the Point Beach Nuclear Power Plant located in Two Creeks, Wisconsin, and two fossil-fueled plants, the Waukegan Generating Station located in Waukegan, Illinois, and the State Line Generating Station located in Hammond, Indiana. (auth)

**22504** INVESTIGATION OF THERMAL EFFLUENTS IN WAKASA BAY. Niwa, S. (Fukui Prefectural Fisheries Experimental Station, Tsuruga, Japan). Genshiryoku Kogyo; 18: No. 9, 23-27(Sep 1972). (In Japanese).

Concentration of chlorine and temperature at depths of 0, 1, 2, 3, 4, 5, 7, 10, 15, 20m were observed at 26 points of observation with salinometers and thermistors, in the sea extending over a 3,000m radius from the exit ends of hot drain discharged from Tsuruga Atomic Power Plant into Urazoko Bay and from Mihama Atomic Power Plant into Tanjo Bay. Both plants are located at the opposite sides of Tsuruga Peninsula. In addition, the composition and amount of plankton at a depth of 20m were observed with vertical drawing plankton nets, and formation of the growing groups of living things such as seaweeds, shellfishes and benthos, was investigated quarterly as preliminary investigation since 1970. A layer of hot effluent having a temperature 6°C higher than the surface layer spreads over a 1,500 to 2,000m radius area in Tanjo Bay from the exit end of drain at the rate of 20 tons per second, while the affected area spreads sometimes over 3,000m in narrow Urazoko Bay, and its temperature difference is 1°C at the surface of seawater. The thickness of the warm layer is 2 to 4m near the exit end of drain. On the other hand, the layer with the temperature difference of 3°C spreads over a 200 to 400m radius with a thickness of 1 to 2m in the wide bay and 3 to 4m in the narrow bay. These data are related to complicated changes in marine and atmospheric phenomena, configuration of ground, and systems of intake and drain. (auth)

# INSTRUMENTATION

## Radiation Detection Instruments

### General Detectors and Monitors

*Refer also to abstracts 23003, 23051, and 23766.*

**22505** (AD–749863) USE OF PLASTIC DETECTORS TO CONFIRM THE ACCELERATION OF ARGON NUCLEI TO RELATIVISTIC VELOCITIES AT THE PRINCETON PARTICLE ACCELERATOR. Fitz, R. C.; McNulty, P. J.; Davis, A. F. (Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.). 25 May 1972. 13p. (AFCRL–72-321; AFCRL-PSRP-493). NTIS.

Argon ions were recently accelerated to 11.7 GeV at the Princeton Particle Accelerator. This represents a two-fold increase in the mass over particles previously accelerated to relativistic energies. The report describes how a stack of cellulose nitrate track detectors was used to confirm the successful acceleration with the unambiguous identification of 79 argon tracks within a clearly defined 1 ¼-inch-beam spot. (auth)

**22506** (AE–455) LONG-TERM TEST OF SELF-POWERED NEUTRON DETECTORS IN HBWR. Brakas, M.; Strindehag, O.; Soederlund, B. (Aktiebolaget Atomenergi, Studsvik (Sweden)). Jun 1972. 25p. Dep. NTIS (U. S. Sales Only).

A long-term test of neutron detectors in the Halden Heavy Boiling Water Reactor has shown that self-powered detectors have excellent reliability. The present investigation, started in September 1968 and still continuing (April 1972), involves 54 vanadium and cobalt detectors type 5503 (AB Atomenergi). In regard to the high operating temperature the reliability of self-powered detectors seems to be comparable with that of many electronic components. Considering also the high radiation fields in which the detectors are working the reliability found is still more impressive. (auth)

**22507** (BMBW-FBK-72-26) TRANSVERSE INCORE PROBE SYSTEM FOR THE CALIBRATION OF FIXED FISSION CHAMBERS. Stimler, M. (Allgemeine Elektricitaets-Gesellschaft, AEG-Telefunken, Frankfurt am Main (West Germany)). Dec 1972. 31p. (In German). Dep. NTIS (U.S. Sales Only).

The development program of a tip system has the aim to develop a system for serial manufacture, which is able to calibrate the fixed fission chambers distributed in-core for power measurement losing their sensitivity by burnup and which can detect the axial neutron flux distribution. The calibration is made automatically. Details of the construction and manufacture of the prototype-system and control-system, tests, and a long-time test are given. The results of the tests and the experience for the serial type are discussed. (auth)

**22508** (BNWL–SA–4227) INTERCALIBRATION FOR LOW-ENERGY PHOTON MEASUREMENTS. Swinth, K. L.; Dean, P. N. (Battelle Pacific Northwest Labs., Richland, Wash.; Los Alamos Scientific Lab., N. Mex.). 1 May 1972. Contract AT(45-1)-1830. 21p. (CONF-720614-8). Dep. NTIS $3.25.

From 17th annual meeting of the Health Physics Society; Las Vegas, Nevada, USA (12 Jun 1972).

In 1970 an informal group of scientists working on the in vivo measurement of low-energy photon emitters (plutonium) convened to consider an intercalibration program for plutonium whole body counters. It was decided that an intercalibration program should be undertaken in three phases. First, pertinent data on the photon emissions fron the transuranic materials should be compiled; and second, the counters should be intercompared with a source and, finally, the same subjects with a body burden of plutonium should be counted at the participating laboratories. Preliminary results from the source intercalibration of participating facilities are summarized. Three sources each of $^{241}$Am and of $^{238}$Pu, representing three decades of activity, were routed to participating laboratories along with instructions, a counting jig and absorbers. The laboratories were to count the various sources in a fixed geometry with and without the absorbers and to determine the source activity with their own standard. The first reports for the high level $^{241}$Am source (50 to 70 keV energy band) had a mean of 589 nCi and a standard deviation of 34 nCi. The range was 90 nCi. For the high-level $^{238}$Pu source, the mean was 385 nCi with a standard deviation of 35 nCi. The range was 102 nCi. Results with the other sources are similar with variations greater than expected from statistics. (auth)

**22509** (FEI-265) PROCESSING TECHNOLOGY OF γ-RADIATION Ge(Li)-DETECTORS. Gamalii, A. F.; Nesterov, B. V. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Energeticheskii Institut). 1971. 13p. (In Russian). INIS.

A method is described for processing the surface of Ge(Li) detectors, and facilitates the determination of current leakage in the detectors within the limits $10^{-11}$ to $10^{-10}$ A under a bias of 1500 V with reproducible results. Transition boundaries at low temperatures may be obtained relative to the deposition of hoarfrost from the ambient atmosphere. Precipitation of Li was manifest during heating. Detector characteristics and gamma ray spectra from different sources are adduced. (tr–auth)

**22510** (FRNC-TH-228) FAST NEUTRON FLUENCE DETECTOR UTILIZING THE $^{93}$Nb(n,n')$^{93m}$Nb REACTION. Hegedus, F. (Strasbourg Univ. (France)). 1972. 120p. (In French). INIS.

Thesis.

A fluence detector was developed for fast neutrons. It is made of Nb which undergoes the following reaction: $^{93}$Nb(n,n')$^{93m}$Nb. The detector is compact and has an almost energy independent sensitive surface. A long half-life isotope is produced. This detector is more suitable for use in a nuclear reactor than those currently used. In evaluating the fluence from the measured activity of the 16.6 keV X($K_\alpha$) line of $^{93m}$Nb, the following parameters were utilized: the activation cross section, the K shell conversion coefficient, and the half-life of the $^{93m}$Nb isotope. Since accurate values were not available for these parameters, it was necessary to measure them. The activation cross section was determined as a function of energy using a comparative method. The following values were obtained: $\sigma = 36.4 \pm 0.3$ mb, $120.6 \pm 12.2$ mb, and $134.2 \pm 15$ mb for energies of $0.1 < E < 1.0$ MeV, $1.0 < E < 4.0$ MeV, and $4 < E < 15$ MeV respectively. The conversion coefficient of the K shell electrons was used to determine the decay rate of the $^{93m}$Nb isotope. The $\alpha_K/\alpha$ ratio was measured to be $0.172 \pm 0.035$. The half-life of $^{93m}$Nb was found to be $11.44 \pm 0.9$ years. This detector is already being used in several reactors. (auth)

**22511** (FRNC-TH-303) SIMULATION STUDIES OF VARIOUS TYPES OF MODEL FOR COUNTERS WITH DEAD TIMES AND COUNTER WITH PULSE SUPPRESSION. Khelladi, A. (Clermont-Ferrand Univ. (France)). 1972. 158p. (In French). Dep. NTIS (U. S. Sales Only) $10.00.

The theory of particle counters is based upon an understanding of particle emission processes. A simple model is used in which the particles received by the counter arrive according to a homogeneous Poisson distribution having a parameter lambda. The counter recording process does not correspond to a real emission process as each particle may give rise to a blocking (or dead time) dependent upon the pulse duration. Two types of constant dead time counters are distinguished: type M1 (Geiger Muller) and type M2 (electron multiplier). The pulse shaping process involves the suppression of the pulses induced by certain particles. Two types of conditional pulse suppression methods are distinguished: E1 and E2; a last type of counter is envisaged: the mixed type (M2E1 and M2E2) in which all the particles producing pulses are associated with a certain dead time. The methods used to estimate the parameters are given including a method of moments for all types of counters and method of maximum likelihood for M1, M2 and E1 type counters. A means of simulating the renewal processes encountered is proposed. An attempt is made to establish the value of the parameters using the estimation methods developed. (FR)

**22512** (LA–5195-MS) PROPORTIONAL CHAMBERS WITH MONOFILAR HELICAL CATHODES FOR HIGH SPATIAL RESOLUTION. Lee, D. M.; Sobottka, S. E.; Thiessen, H. A. (Los Alamos Scientific Lab., N. Mex.). Mar 1973. Contract W-7405-eng-36. 10p. Dep. NTIS $3.00.

Multiwire potential chambers with monofilar helical delay line cathodes have been developed. Spatial resolutions better than 0.33 mm FWHM have been achieved. Such chambers are easily constructed and read out and can be adapted to a large variety of geometries. The properties of monofilar helical delay lines are analyzed in detail. (auth)

**22513** (ORNL-TM-4149) MONTE CARLO ANALYSIS OF AN NE213 DETECTOR. Cramer, S. N. (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 21p. Dep. NTIS $3.25.

A Monte Carlo analysis of an NE213 detector has been performed using the ESP code. The investigation involved calculation of the alpha particle and proton spectra produced in the detector from neutron reactions with hydrogen and carbon. The sensitivity of these calculated spectra has been determined with respect to first collision only, hydrogen scatter only, and reaction Q value. (auth)

**22514** (RFP–1972) ALPHA-PARTICLE DETECTOR SYSTEM FOR MONITORING PERSONNEL. Tyree, W. H.; Bell, T. H. (Dow Chemical U. S. A., Golden, Colo. Rocky Flats Div.). 2 Feb 1973. Contract AT(29-1)-1106. 2p. Dep. NTIS.

An improved alpha-particle detector system has been designed for monitoring personnel working in areas where radioactive materials are handled. The unit operates effectively to monitor clothing and booties worn by personnel, as well as body areas. No manipulation of controls is required for operator use. Incorporating two counter modules, one as a hand monitor and the other as a foot monitor, the system provides visual and aural readout for pulses received from air-proportional detectors. As designed, the unit does not require extra housing for electronics and batteries. Thus, a cost savings has been realized over earlier models of about $400. The system also operates more efficiently and with less maintenance. (auth)

**22515** (RT/EL-(72)7) LOGARITHMIC GAMMA MONITOR. Cervellati, R. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 21 Jun 1972. 34p. Dep. NTIS (U. S. Sales Only) $3.75.

A gamma monitor with a logarithmic scale for the 10 mr/h to 10 r/h range is described. In the monitor a high current GM tube is used together with a log counting-rate meter. The GM tube characteristics and the theoretical behavior of the log circuit are presented in detail. (auth)

**22516** (UCID–16091) DETECTOR CALIBRATION TECHNIQUES, X-RAY MACHINE INTENSITIES AND FLUORESCENT X-RAY SPECTRUM CATALOG. Gaines, J. L.; Ebert, P. J.; Leipelt, G. R. (California Univ., Livermore. Lawrence Livermore Lab.). 3 Nov 1967. Contract W-7405-eng-48. 60p. Dep. NTIS $5.00.

The experimental setup is described and data are given for near monoenergetic fluorescent x-ray sources with known effective source strengths for calibration of detectors. Characteristic fluorescent x rays from very pure targets placed in the beam from a dc x-ray machine are filtered using k-edge post filters. Approximate fluorescent energy source strengths and fluorescer and filter combinations used with different x-ray machines are listed. A catalog of spectra from a number of fluorescer–filter combinations is included. (WAK)

**22517** (UCRL–73978) RISETIME DISCRIMINATOR FOR LOW LEVEL TRITIUM COUNTING. Bradley, A. E.; Willes, E. H. (California Univ., Livermore. Lawrence Livermore Lab.). 5 Dec 1972. 13p. (CONF-721202-9). Dep. NTIS.

From Nuclear Science Symposium; Miami Beach, Florida, United States of America (USA) (6 Dec 1972).

The design of a risetime discriminator circuit (RTD) with associated anticoincidence/coincidence (AC/C) logic and its application to the counting of low-activity tritium samples in gas proportional counter systems are described. The circuitry, packaged in a double-width NIM, extracts signal risetime information which is used in conjunction with the output of an annular guard counter to electronically reject background counts due to high energy charged particles ($\mu$-mesons), and gamma-ray photons. (auth)

**22518** SEMICONDUCTOR DIODE COUNTER AND ITS MANUFACTURE. Digoy, J. L. (to La Radiotechnique-Compelec). French Patent 2,108,781. 26 May 1972. Filed date 5 Oct 1970. 11p. (In French)

A diode counter is presented. It consists of a semiconducting substrate provided with at least two superposed layers having the same type of conductivity. The first region in which the counting junction is formed has a high resistivity; the second region is heavily doped with impurities and has a thickness of at least the diffusion length of the minority carriers; the impurity concentration in this second region increases slowly with the distance from the surface separating the first and second region. This structure enables leakage currents due to the presence of minority carriers to be reduced. This is achieved by the barrier provided beneath the photosensitive junction. This barrier may be either in the form of a second reverse biased junction, or in the form of nonbiased zone which can be considered as a junction. In this way a high breakdown potential is achieved. (FR)

**22519** RADIATION DETECTOR DEVICE. Allard, G.; Lansiart, A. (to Commissariat a l'Energie Atomique). French Patent 2,111,992. 16 Jun 1972. Filed date 30 Oct 1969. 7p. (In French).

A gas radiation detector, which can be used as a spark chamber and which provides a visual display of the spatial distribution of x or $\gamma$ rays in an enclosure containing an ionizable gas mixture and three parallel electrodes (transparent cathode, grid and anode) is presented. The ionization phenomena are induced by the incident radiation in the gas medium of the grid cathode space. A multiplying space is created by the anode in which the electrons created in the detecting space multiply after having traversed the grid giving rise to sparks. The device is also provided with an external electronic circuit which connects the anode and the grid and is triggered off the sparks produced in the multiplying space temporarily short circuiting this space at the occurrence of each spark. The anode consists of two conducting deposits in electrical contact on the two faces of an optically transparent substrate, the first deposit having a large surface resistance and limiting the multiplying space, and the second deposit having a small surface resistance. (FR)

**22520** ACTIVATION DETECTOR AND ITS MANUFACTURE. Leger, P.; Salon, L. (to Commissariat a l'Energie Atomique). French Patent 2,116,212. 13 Jul 1972. Filed date 27 Oct 1970. 6p. (In French).

A new type of activation detector is presented in which a metallic element is activated by the flux to be measured. The device includes a fine metallic wire element which has been degassed at high temperature and enclosed under secondary vacuum in a leak-tight silica glass envelope. This type of detector can be used to detect neutrons inside a nuclear reactor and in high temperature environments (greater than 1200°C) during long periods of time (exceeding several weeks or perhaps several months). (FR)

**22521** DEVICE FOR SIGNALING A RAPID RADIOACTIVE CONTAMINATION. Chaud, A.; Da Costa Vieira, D.; Friedling, G.; Suzan, H.; Vieuxmaire, C. (to Commissariat a l'Energie Atomique). French Patent 2,108,138. 19 May 1972. Filed date 20 May 1970. 14p. (In French).

A device for signaling a rapidly occurring radioactive contamination due to the leaking of a radioactive gas in channels of a vessel is presented. This accidental contamination can be detected in the presence of a high degree of residual contamination due to the presence of radioactive substances. The device can be used to ensure the safety of personnel. The signals of interest are separated from the background noise by a technique involving the use of the different respective variations with respect to time. The device has an n channel detection system, each channel possessing a radiation detector which delivers the signals of interest and the background signals to a matching circuit, a counting scaler, and a common circuit consisting of a clock signal generator delivering periodic pulses, a circuit distributing the clock signals, and a direct measurement channel provided with a circuit for selecting the signals from each scaler in view of continuously recording the information from each scaler and of comparing this information with a certain threshold value. (FR)

**22522** METHOD AND APPARATUS FOR EVALUATING THE DEGREE OF QUENCHING IN SCINTILLATION SPECTROMETRY. Rosenstingl, E. (To Intertechnique SA). U. S. Patent 3,715,584. 6 Feb 1973. Priority date 21 Nov 1969, France. 14p.

For evaluating the degree of quenching in a liquid scintillation sample, the pulse height corresponding to the centroid of part at least of the net count rate—pulse height spectrum due to a radioisotope in the sample or to an external standard is determined and compared with a calibration curve. Provision is made for subtraction of the contribution of the background noise. Determination of the counting efficiency is made by interpolation on a calibration curve. (Official Gazette)

**22523** BATTERY-CHARGING STORAGE RACK FOR PORTABLE INSTRUMENTS. Powell, T. J. (Univ. of Michigan, Ann Arbor). Health Phys.; 24: No. 4, 441-442(Apr 1973).

To overcome the nuisance and irritation of routine changing of batteries in portable equipment such as radiation survey instruments, it is suggested that nickel-cadmium batteries should be incorporated in such equipments and a battery-charging storage rack used. The facility described is a simple way to recharge the batteries in a large number of instruments without the confusion of having a variety of battery chargers for different instruments. (UK)

**22524** RADIATION AND ALARM SYSTEM (AMOS II) FOR HABITABLE AREAS OF AN ACCELERATOR COMPLEX. Picinich, L. M.; Distenfeld, C. H. (Brookhaven National Lab., Upton, NY). Health Phys.; 24: No. 4, 442-443(Apr 1973).

High radiation doses to personnel are always possible in working areas of the Alternating Gradient Synchrotron (AGS). AMOS II is an integrating detection system designed to indicate local radiation dose rates, and to initiate an alarm when a predetermined dose rate level is reached. The radiation environment at AGS consists of a mixture of high-energy particles and photons, the majority of which are produced during targeting, and are manifested in pulses of from 2 ns to 400 msec duration. AMOS II responds to such pulses, and is therefore suitable for use in most installations in which pulsed radiations are encountered. The three sections of the monitor, detector, alarm and ratemeter are briefly described. (UK)

**22525** HIGH-RESOLUTION NEUTRON SPECTRUM MEASUREMENTS IN THE SANDIA PULSED REACTOR-II FACILITY. Powell, J. E. (Sandia Labs., Albuquerque, NM). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 186-193(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

High resolution neutron spectrum measurements were made in the SPR-II glory hole, at 2.5, 15, 76 and 214 cm outside the core and in the beam port facility with proton-recoil gas proportional counters. The energy ranges were a few keV to 2.7 MeV depending upon the location and the resolution was 12% ($\Delta E/E$, FWHM) over most of the energy range. The data showed that the exterior spectra were somewhat softer than that in the glory hole due to the influence of room return neutrons. Comparisons were made with fission couple measurements and Monte Carlo calculations at the glory hole and 2.5 cm positions. A composite spectrum from 12 keV to 8 MeV was formed from the proton-recoil and fission couple results. Silicon displacement damage was calculated for the various reactor positions using the different spectra. (auth)

### Radiation Dosimeters

*Refer also to abstracts 22618, 22624, 22715, 22732, and 22762.*

**22526** (AD-750342) ANISOTROPIC DOSE AND ITS APPLICATIONS IN DIRECTIONAL RADIATION SENSING. Kronenberg, S.; Lux, R. A.; Ramm, W. J.; Nilson, K. L.; Pfeffer, R. L. (Army Electronics Command, Fort Monmouth, N. J.). 1972. 12p. NTIS.

While conducting radiation experiments using polyvinyl chloride and photographic film as dosimeters, anomalous "hot spots" in dose delivered to regions where there was a perturbation in the atomic number Z close to the dosimeter were noticed. These increases in local dose were strongly dependent on the direction of the incident radiation and could be observed even when the perturbation was a very thin layer of different Z material. Such perturbations can affect measurements of gamma and X-ray doses and may be responsible for serious errors in dosimetry if one is not aware of their existence. This effect is discussed. (NTIS)

**22527** DOSIMETRIC CONTROL. Blanchard, J. C.; Laizier, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 49-52(Jun 1972). (In French).

The direct effect of radiation doses on the costs involved in irradiation processes is a very important factor. The various dosimetry techniques used in conjunction with CAPRI for $\gamma$ radiation and electrons (having high and low energies) used for calibrations and in routine operations are described. (FR)

**22528** DOSE-RATE RESPONSE OF A DYE-POLYCHLOROSTYRENE FILM DOSIMETER. Chappell, S. E.; Humphreys, J. C. (National Bureau of Standards, Washington, DC). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 175-180(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

The response of dye-polychlorostyrene film dosimeters is compared at low ($\sim 10^3$ rad/sec) and high ($\sim 10^{15}$ rad/sec) dose rates. Low dose rate exposures were obtained with a $^{60}$Co gamma-ray pool source, and high dose rates were obtained with a high-intensity, pulsed electron source. The dosimeter is a solid solution of polychlorostyrene and malachite green methoxide which changes color upon irradiation. Two broad absorption peaks appear in the visible region with maxima at about 425 and 625 nm. The change in optical density of the 625-nm peak was monitored and correlated to the absorbed dose received by the dosimeters. At low dose rates, the source output was determined on the basis of a previous calibration with a carbon calorimeter and a cavity ionization chamber; at high dose rates, a thin dosimeter calibration system was employed. The calibration system has as its primary measuring elements aluminum calorimeters whose temperatures after exposure were monitored by chromelconstantan thermocouples. Associated electronics recorded the outputs of the thermocouples at every 0.1 sec. In the two cases, the dosimeters were exposed in a different but homogeneous medium, carbon or polystyrene at the low dose rates and aluminum at the high dose rates. In addition, Monte Carlo calculated stopping power ratios of the dye-film dosimeter to the medium were required to interpret the dose received by the dosimeters. The results indicate that there is no significant difference in the response at the two different rates. (auth)

### Nuclear Spectroscopic Instrumentation

*Refer also to abstract 23398.*

**22529** (AERE-M-2570) COLLECTION AND PROCESSING OF DATA FROM THREE TIME-OF-FLIGHT NEUTRON SPECTROMETERS. Baston, A. H. (Atomic Energy Research Establishment, Harwell (England)). Nov 1972. 40p. Dep. NTIS (U. S. Sales Only). UK 1.00 pound.

This report is an updated and expanded version of "Notes on the Analysis of Neutron Scattering Data" edited by G. D. Wignal, A.E.R.E. M 1928, which was written in 1967. Since that time the method of collecting the data has been changed radically, computer programs used in the reduction of data have been streamlined and improved, and two more spectrometers are dealt with. There is less full treatment of corrections for single and multiple scattering and absorption in samples and cans, these subjects being considered beyond the scope of this report. The existence of factors for applying such corrections in the relevant program is indicated and any built-in expressions for specific purposes are described. (auth)

**22530** (INS-TL-120) PROGRAM OF ON-LINE DATA PROCESS FOR INS FM ANALYZER. Kokame, J.; Ogata, H. (Tokyo Univ. (Japan). Inst. for Nuclear Study). 18 Jul 1972. 42p. (In Japanese).

A computer program was developed for on-line data processing of spectra measured with the INS FM analyzer system. Data taken with the PDP-9 are transferred to the central computer (TOSBAC-3400/M41) where automatic background estimations and peak searches are made. All procedures to reduce the raw data to the differential cross section are made in the central computer. The results are transferred back to the PDP-9 or printed out on a terminal typewriter (10T). This manual discusses the operation and how to use the program with an example. (auth)

**22531** (IS-T-562) MAGNETIC FIELD CONTROL IN A BETA-RAY SPECTROMETER. Halbig, J. K. (Ames Lab., Iowa). Nov 1972. Contract W-7405-eng-82. 40p. Dep. NTIS.

Thesis. Submitted to Iowa State Univ.

Topics include spectromagnetic supply-spectrometer subsystem; alpha scientific supply-solenoid subsystem, magnetometer-probe subsystem; and non-constant permeability effects. (WHK)

**22532** (JAERI-1223) PARTICLE COLLIMATION IN RADIATION DETECTORS AND ITS APPLICATIONS FOR NEUTRON SPECTROMETRY. Mizuho, M. (Japan Atomic Energy Research Inst., Tokyo). Aug 1972. 49p.

Several types of gas recoil fast neutron spectrometers were constructed and their performances investigated including newly developed methods for particle collimation. A spectrometer of the intermediate-thickness radiator type with a multi-hole collimator was constructed. The spectrometer was composed of three methane-filled proportional counters (A, B, and C) arranged end-to-end (tandem) with a common center wire (anode). Between counters A and B there is a collimator with many holes which work as a proton collimator. A summing problem constantly encountered in the conventional spectrometers of this type was eliminated by using anode pulses for the neutron energy. A fast coincidence between the pulses from the counters A and B reduced the chance coincidence by a factor of ~5. A method of electronic collimation using the newly developed scheme with fast coincidence was introduced in the system of proportional counters. The collimation characteristics were investigated using an alpha source, then the method was applied to the neutron spectrometry with monochromatic neutrons of 0.6 to 1.5 MeV. A coincidence faster than 100 ns was possible, resulting in more reduced chance coincidences. Another method of electronic collimation was also developed with a rise-time discrimination in the conventional counter. The collimating performance of the new method was also examined with alpha particles, then the feasibility of a new scheme of the neutron spectrometer was indicated. Both methods, however, still had some defects concerning the background. These were removed by combining the two methods. The rise-time discrimination in the gridded ionization chamber could also be used for particle collimation. The method was used for the angle measurement and proved to be a new type of neutron spectrometer with a thin radiator foil. It also improved the spectrum quality in the alpha spectrometry. (auth)

**22533** (JAERI-M-5016) COMPUTER PROGRAM FIT-I FOR FITTING GAMMA-RAY SPECTRUM FROM SEMICONDUCTOR DETECTORS. Tasaka, K. (Japan Atomic Energy Research Inst., Tokyo). Oct 1972. 45p. (In Japanese). NTIS (U. S. Sales Only).

The computer program FIT for analysis of the $\gamma$-ray spectrum by the method of least squares was prepared previously. This program has been modified to calculate the photopeak component at each channel by integration of the shape function over the channel width. The program can determine accurately the peak energy, peak intensity and FWHM (full width at half maximum) of each photopeak even when the channel width is large and the shape of each photopeak is expressed by the data in a few channels. (auth)

**22534** CALIBRATION OF GAMMA-RAY SPECTROMETERS FOR GROUND AND AIRBORNE USE. Grasty, R. L.; Darnley, A. G. Geological Survey of Canada, Paper 71-17. Ottawa; Department of Energy, Mines, and Resources (1971). 30p. Information Canada, Ottawa.

The calibration of field gamma-ray spectrometers for measuring the abundance of potassium, uranium, and thorium requires radioactive sources of effectively infinite size. Five large radioactive calibration slabs (25 feet by 25 feet and 18 inches thick) have been constructed for this purpose and the techniques used to determine the sensitivities and Compton scattering coefficients of field gamma-ray spectrometers are described. Results obtained for 3 gamma-ray spectrometers, used by the Geological Survey of Canada, are presented. (auth)

**22535** FORTRAN PROGRAM FOR AUTOMATIC CALCULATION OF GAMMA SPECTRA OF Ge(Li) DETECTORS WITH A SMALL ELECTRONIC COMPUTER. Travesi, A.; Adrada, J.; Palomares, J. (Junta de Energia Nuclear, Madrid). pp 89-109 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972). (In Spanish).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

The GAMMAS program, written in Fortran, is described for the resolution and automatic calculation of gamma spectra obtained with Ge(Li) detectors, permitting gamma spectra of any number of channels to be processed by an electronic computer having a memory limited to 8000 words. It can be used with small high-speed electronic computers which, thanks to their lower cost, are accessible to laboratories with a limited budget. The program permits the automatic processing of spectra punched on paper tape in ASCII or similar code, supplied by any type of a multichannel analyzer. Only a few data, such as the number of channels on the tape and the calibration data, are fed manually to the computer via teleprinter or card, the rest of the process being entirely automatic. The criteria adopted for localizing the photopeaks and their edges as well as for determining the spectrum background through the generation of a baseline by an iterative process of eliminating the photopeaks, based on the statistical significance of the counts accumulated in each channel, which makes it possible to obtain the correct background below the photopeak are described. The program includes options for calculating the areas of the photopeaks by three different methods, the total area method, and the Covell and Wasson methods; and also for obtaining a series of sections of the spectrum which can be selected at will, with data on the content of the channel and of the baseline, for examination when necessary. It is possible to handle spectra of an unlimited number of channels with a limited memory thanks to the part-by-part resolution of the spectrum and rotation of the data in the memory. Apart from providing the position and the edges of the photopeak, the program gives the energy in keV, the resolution and also the area expressed in counts per minute, calculated according to the method selected, the statistical measuring error, the background and the qualitative detection limit of the photopeak. The program flow diagrams, as well as some examples of its application to neutron-activated biological samples, by means of a high-speed Hewlett-Packard 2114B computer with an 8000-word memory are included. Finally, the precision and reproducibility of the experimental results are analyzed. (auth)

**22536** MODIFICATION IN MI-1305 TYPE MASS SPECTROMETER. Varga, G.; Beczner, K. (MTA Talajtani es Agrokemiai Kutato Intezet, Budapest). Izotoptechnika; 16: No. 1, 32-36 (Jan 1973). (In Hungarian).

The modifications made to a Type MI-1305 mass spectrometer are described. The spectrometer is used for the routine measurement of $^{15}$N abundance in small nitrogen samples. (auth)

**22537** ESTIMATION OF NEUTRON SPECTRA FROM EXPERIMENTAL PROTON RECOIL DATA. Mutone, G. A. Manhattan, KS; Kansas State Univ. (1972). 146p. University Microfilms Order No. 73-1169.

Thesis (Ph. D.).

A method to unfold neutron spectra from experimental proton recoil data in the form of a multichannel pulse height analyzer histogram is developed and tested. Since the energy spectrum of a neutron source is essentially the probability density function of the energy with which neutrons are emitted the theory of random variables is used to develop the basic unfolding method. Time series analysis and Fourier analysis are subsequently applied to obtain smooth estimates of the neutron spectra. The method is tested by its application to experimental data produced with an NE-213 fast neutron spectrometer system and a Benjamin-type spectrometer system. The spectral estimates are compared with calculations, published data and results obtained with the ORNL unfolding code FERDOR. The technique developed does not require a response matrix associated with the detection system and, in the case of the Benjamin system, does not require the knowledge of the neutron spectrum above the maximum energy for which the spectrometer is designed. (Diss. Abstr. Int., B)

**22538** RELATION BETWEEN AN ELECTRONIC CIRCUIT DYNAMIC VOLTAGE GAIN CHANGES AND ITS INTEGRAL NONLINEARITY. Bayer, R. (Inst. of Nuclear Research, Swierk, Poland). Nukleonika; 17: No. 7/8, 417-420(1972).

Various definitions of circuit nonlinearity are given and compared. The relation between the voltage gain changes and integral nonlinearity is found. The dynamic voltage gain changes and integral nonlinearity of the source follower are theoretically calculated and compared with the results obtained experimentally. (auth)

## *High Energy Physics Instrumentation*

**22539** (IFVE-SPK-71-92) PROBLEM OF IMPROVING THE UNIT CRT WITH RESOLUTION FOR SCANNING AUTOMATIC UNITS. Utochkin, B. A.; Rabin, B. M. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1971. 15p. (In Russian). INIS.

Methods of decreasing focusing aberrations and deflections in a cathode ray tube of high resolving ability are described. The system has an application as a light spot generator for automatic scanning and processing photographs of a track chamber. New tubes with high voltage compression of the electron beam and tubes with a quasi-laminar electron beam simplify the approach to the production of nodal points of the cathode ray tube since they eliminate the necessity of complex dynamic corrections in focusing and astigmatism. The technical characteristics are thereby improved, and the reliability of the tube nodal points is enhanced. (tr-auth)

**22540** (ITEF-893) STEREOPROJECTOR FOR PROCESSING PHOTOGRAPHS REGISTERED IN 180-LITRE XENON BUBBLE CHAMBER. Barmin, V. V.; Barylov, V. G.; Demidov, V. S.; Makarov, Yu. I.; Shebanov, V. A. (Gosudarstvennyi Komitet Po Ispol'Zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi I Eksperimental'Noi Fiziki). 1971. 8p. (In Russian). INIS.

A stereoprojector has been designed for the identification and measurement of events taking place in the ITEF 180-liter bubble chamber. The error in measuring the coordinate points of track intersections in space amounted to 0.3 to 0.5 mm in a plane perpendicular to the optical axis, and 0.5 to 1.0 mm in the direction of the optical axis. The accuracy of angular measurement by the stereoprojector is 0.5°. The position of reference crosses of the chamber is such that the difference in scales of the projection along the coordinate axes do not exceed 1% of the transverse dimensions of the chamber. Experience in processing photographs with the stereoprojector shows that the time required for measuring the angular coordinates of an event consisting of six $\gamma$-quanta amounts on the average to 8 to 10 min. The stereoprojector is provided with circuitry which automates the process of computing the coordinates and angles and recording the results on punched tape. (tr-auth)

**22541** (ITEF-909) ASPIK: THE PROGRAMME OF THE SPARK CHAMBER PHOTOGRAPH PROCESSING IN MAGNETIC FIELD. Efremenko, V. I.; Zaitsev, Yu. M.; Illarionova, N. S.; Ol'shanetskii, M. A.; Suchkov, D. A. (Gosudarstvennyi Komitet Po Ispol'Zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi I Eksperimental'Noi Fiziki). 1972. 12p. (In Russian). INIS.

The ASPIK program was designed to process stereoscopic photographs taken in spark chambers in a magnetic field. The program makes possible the reconstruction of the spatial picture of events along designated coordinates in connection with individual flashes and reference marks. The apex of events and also the momenta and flight angles of all particles may be determined. (tr-auth)

**22542** (JINR-P10-6868) EXACT CONSIDERATION OF THE BREMSSTRAHLUNG FLUCTUATIONS IN ELECTRON TRACK PARAMETER DETERMINATION. Moroz, V. I.; Stel'makh, A. P.; Tentyukova, G. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Computing Techniques and Automation). 1972. 14p. (In Russian). Dep. NTIS (U. S. Sales Only).

Kinematic parameters of electron tracks in propane, propane-Freon, and hydrogen-neon bubble chambers were determined from the extremum condition of the likelihood maximum function which includes the V. Geitler's distribution of radiation losses. The program is constructed realizing the algorithm of the nonlinear problem solution. (auth)

**22543** (JINR-P10-6869) DETERMINATION OF THE KINEMATIC PARAMETERS OF THE ELECTRON TRACKS USING NORMAL DISTRIBUTION WHEN TAKING INTO ACCOUNT THE FLUCTUATIONS OF RADIATION LOSSES. Moroz, V. I.; Stel'makh, A. P.; Tentyukova, G. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Computing Techniques and Automation). 1973. 22p. (In Russian). Dep. NTIS (U. S. Sales Only).

The problem of determination of the electron track parameters in a propane bubble chamber based on the least-squares method is considered. Special attention is given to the choice of the calculation branch depending on the track length. (auth)

**22544** (KFTI-72-16) TELESCOPE FOR IDENTIFICATION OF RELATIVISTIC ELECTRONS AND POSITRONS. Titov, Yu. I.; Akhmerov, R. V.; Byvalin, S. A.; Pilipenko, A. M.; Smelov, E. M. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1972. 8p. (In Russian). INIS.

A telescope was developed for identifying electrons and positrons after magnetic separation. The telescope consists of three scintillation and threshold gas Cherenkov counters. The gas counter contains 20 atmospheres of $CO_2$. Light pulses are recorded with a photoelectron multiplier FEU-30. The recording efficiency for electrons was at least 99.5%. (tr-auth)

**22545** (LBL-797) EXTERNAL MUON IDENTIFIER DEVELOPMENT: HALF METER PROPORTIONAL CHAMBER TEST RESULTS. Parker, S.; Jones, R. (Hawaii Univ., Honolulu; California Univ., Berkeley. Lawrence Berkeley Lab.). May 1972. Contract AT(04-3)-511. 48p. (UH-511-122-72). Dep. NTIS.

A half scale multi-wire proportional chamber was built to determine the optimum gap and to test several proposed features of the 1 meter chambers that will form the elements of the NAL 15' bubble chamber external muon identifier. The chambers and their readout system are designed to be simple and inexpensive, with machining minimized in the construction. The main features are: (1) three coordinate readout—X, Y and U (diagonal), using only one wire plane; (2) a copper strip—plastic laminate that serves as a gas barrier, cathode, and conveyer of induced signals for the Y and U coordinates; (3) an electromagnetic delay line readout that also provides a prompt timing pulse; and (4) a wire-to-wire separation (5 mm) sufficiently large to prevent electrostatic instability without the need for supporting structures. (auth)

**22546** (UH-511-145-73) NEUTRON BEAM MONITOR FOR NAL EXPERIMENT 87. Yount, D. (Hawaii Univ., Honolulu. Dept. of Physics and Astronomy). Feb 1973. Contract AT(04-3)-511. 14p. Dep. NTIS.

A shower counter consisting of alternating layers of iron and scintillation detectors for detection of high-energy neutrons is described. The hadron cascade, total thickness, sampling thickness, radial distributions, energy resolution, scintillator, uniformity, and use of the neutron beam monitor are discussed. (WHK)

**22547** TRANSITION RADIATION DETECTOR FOR RELATIVISTIC PARTICLES AT ACCELERATOR ENERGIES. Bamberger, A.; Dell, G. F. Jr.; Uto, H.; Yuan, L. C. L.; Alley, P. W. (Brookhaven National Lab., Upton, NY). Phys. Lett.; 43B: No. 2, 153-156(22 Jan 1973).

Transition radiation (TR) was investigated by using the arithmetic mean and the geometric mean of the pulses from 10 multiwire proportional chambers. The discrimination factor for different kinds of particles was determined. Also the dependence of the intensity of TR on the Lorentz factor $\gamma$ was measured and compared with theoretical calculations. (auth)

**22548** RECOGNITION OF BUBBLE CHAMBER EVENTS EXEMPLIFIED BY THE HEIDELBERG AUTOMATIC SYSTEM. Brokate, K. (IBM Scientific Center, Heidelberg); Erbe, R.; Keppel, E.; Kropp, D.; Grimm, E.; Schneider, H.; Wells, J. Comput. Phys. Commun.; 4: No. 3, 315-326(Dec 1972).

Different methods in use for analyzing bubble chamber pictures and the problem of automating the event recognition process are discussed. A new program system for fully automatic analysis is described and its capabilities are demonstrated. Starting from a digitization of an entire bubble chamber picture (3 stereo views) the program yields space reconstructed and topologically interpreted events. Finally some trends of the future are outlined. (auth)

**22549** INPUT CIRCUIT PARAMETERS AND RESOLUTION TIME OF THE NEUTRON RECORDING CHANNEL OF A SUPERMONITOR. Dolidze, N. I.; Frantsuz, E. T. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.); 12: No. 3, 469-471(1972).

Translated from Geomagn. Aeron.; 12: No. 3, 530-533(1972).

The relation between the resolution time of a neutron supermonitor channel, the signal-to-noise ratio at the input of the amplifier, and its input resistance is investigated. It is suggested that short-circuited delay lines be used to reduce the dead time of the channel without detriment to the signal-to-noise ratio. (auth)

## Radiometric Instruments

**22550** (FEI-301) MEASURING PHASE VELOCITIES AND GAS CONTENTS IN A WATER-AIR FLOW. Kirillov, P. L.; Suvorov, M. Ya.; Shumskii, R. V.; Shtein, Yu. Yu. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Tekhnicheskii Institut). 1971. 38p. INIS.

Gas content in a water-air flow was measured by gamma transmission and by an isokinetic sample. The first method did not introduce perturbations into the flow and could be used in a wide range of variations in the gas content under diabatic and adiabatic conditions of flow of the two-phase medium. The second method, in addition to measuring the gas content, gave information of the structure of the two-phase medium in the form of radial distributions of local values of linear and mass velocities of the phases, coefficients of slip, and weights of gas content. Measurements of the gas velocity profile in the flow of the gas-liquid mixture confirmed the logarithmic law with a diminished constant of turbulence. Two regions with logarithmic dependence were distinguished by the magnitude of the turbulence constants (near the wall, and the central region). Gas content measurements by either the isokinetic probe or by the gamma-translucence method yielded results that were in agreement. (tr-auth)

**22551** (ITJ-35) MEASUREMENTS OF DENSITY PATTERNS OF HYDROMIXTURES BY MEANS OF RADIOMETRIC SCANNING METHOD. Michalik, A. (Institute of Nuclear Techniques, Krakow (Poland)). Oct 1972. 29p. (In Polish). Dep. NTIS (U. S. Sales Only) $3.50.

Results of research carried out on industrial hydraulic installations are reported. Density patterns have been measured by means of a radiometric scanning method. Density distribution of the stowing mixture was measured under the following conditions: flow mean velocity $\bar{v} = 4.0 \pm 10\%$, mean density of the flowing mixture was regulated from $\bar{\rho} = 1.10$ g/cm$^3$ to $\bar{\rho} = 1.90$ g/cm$^3$. Preliminary analysis of about one hundred measured density patterns is described. (auth)

**22552** IONIZATION SMOKE DETECTOR. Kobayashi, A.; Sasaki, K. (to Nittan Co., Ltd.). British Patent 1,299,234. 13 Dec 1972. Filed date 6 Nov 1970. 4p.

An improved ionisation smoke detector is described having a simpler structure than previous instruments. It comprises an outer electrode, an intermediate electrode and an inner electrode. An outer ionisation chamber is located between the outer and intermediate electrodes and an inner ionisation chamber between the intermediate and inner electrodes. A radioactive source is located in one of the ionisation chambers so as to irradiate not only the one chamber directly but also the other chamber through the intermediate electrode. The ionisation chambers are arranged so that the external air enters the inner chamber through the outer chamber. The inner ionisation chamber may be surrounded by the outer ionisation chamber, with the radioactive source on the inner face of the outer electrode. (UK)

## Radiation Effects on Instrument Components, Instruments, or Electronic Systems

*Refer also to abstract 22650.*

**22553** (NIIAR-P-130) METHODS FOR IN-PILE INVESTIGATIONS OF THE RADIATION EFFECTS ON THE ACCURACY OF THE THERMOCOUPLES READING. Markina, N. V.; Samsonov, B. V.; Tsykanov, V. A. (Scientific Research Atomic Reactor Inst., Melekess (USSR)). 1971. 21p. (In Russian). INIS.

Deviations from the normal accuracy of in-pile thermocouple readings were evaluated and the source of such aberrations were elucidated from experimental data. (tr-auth)

**22554** EFFECT OF PROLONGED X-RAY IRRADIATION ON LITHIUM TETRABORATE GLASS DISCS AS USED IN X.R.F. ANALYSES. Le Maitre, R. W.; Haukka, M. T. (Melbourne Univ., Parkville, Australia). Geochim. Cosmochim. Acta; 37: No. 3, 708-710(Mar 1973).

Prolonged irradiation by x rays of lithium tetraborate glass discs causes significant changes in count rates for certain elements, e.g. Na and Mg decrease while Al, Si, and P increase. This effect is probably due to surface diffusion in the glass as grinding away about 10 $\mu$m of the surface of the disc restores the count rates to their original levels. Although no change in count rates will ever be noticed on individual glass discs undergoing routine analyses, where irradiation time is only a minute or so, a close watch must be kept on any specimens that have been irradiated for more than a few tens of hours. (auth)

**22555** DEPENDENCE OF THE THERMOLUMINESCENCE OF LiF:Mg$^{2+}$ CRYSTALS ON THE STATE OF AGGREGATION OF THE Mg$^{2+}$ IONS. Dryden, J. S.; Shuter, B. (National Standards Lab., Sydney). J. Phys., D (London); 6: No. 1, 123-130(1 Jan 1973).

When LiF crystals containing a low concentration of Mg$^{2+}$ ions are irradiated with $\gamma$ rays and then heated, five glow peaks may be observed. The intensity of dielectric absorption is used as a monitor of the state of aggregation of the Mg$^{2+}$-vacancy pairs. It is shown that one of the factors determining the heights of peaks 2 and 3 is the concentration of dipoles in the crystal at the time of irradiation; those Mg$^{2+}$-vacancy pairs present in trimers and larger aggregates make no contribution to the height of these peaks. Both dipoles and trimers contribute to the traps responsible for peaks 4 and 5, but aggregates containing more than three Mg$^{2+}$-vacancy pairs do not contribute. Previous work based on the assumption of a direct proportionality between dipole concentration and the height of peak 2 is invalid. (auth)

**22556** ANNUAL CONFERENCE ON NUCLEAR AND SPACE RADIATION EFFECTS. Conference held in Seattle, Washington, July 24-27, 1972. IEEE (Inst. Elec. Electron. Eng.), Trans, Nucl. Sci.; NS-19: No. 6, 1-418(Dec 1972). (CONF-720707-).

From Annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

Sixty-five papers were presented at the conference. A separate abstract was prepared for each of 54 papers. The remaining 11 papers were previously included in NSA. For abstracts of these see CONF-720707 in the Report Number Index. (WHK)

*For abstracts of individual papers see: 22123, 22525, 22528, 22557-22600, 22872, 23733, 23763-23765, 23806, and 23807.*

**22557** EFFECT OF IONIZING RADIATION ON GUNN-DIODE AMPLIFIERS. Dropkin, H.; Berg, N. (Harry Diamond Labs., Washington, DC). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 11-14(Dec 1972).

From Annual Conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

X-band Gunn diode amplifiers have been tested while exposed to pulsed ionizing radiation. Peak photo currents induced vary as the .65 power of the dose rate, as had been found for oscillator diodes. The principal effect is a transient loss of gain, with the recovery time less than 400 ns for dose rates up to $5 \times 10^{10}$ rad (Si)/s. The dependence of gain on dose rate agrees very well with a calculation based on the change in electric field distribution caused by radiation-induced excess carriers. A permanent failure mode was also observed at the maximum operating voltage and dose rate. (auth)

**22558** NONDESTRUCTIVE SCREENING FOR THERMAL SECOND BREAKDOWN. Tasca, D. M. (General Electric Co., Valley Forge, PA); Peden, J. C.; Miletta, J. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 57-67(Dec 1972).

From Annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

The feasibility of developing nondestructive screening techniques to determine the second breakdown vulnerability of semiconductor devices at submicrosecond pulse conditions has been demonstrated. In addition, it has been shown that second breakdown can be nondestructively initiated under certain current limiting conditions without causing degradation in device operating characteristics or device second breakdown vulnerability level to subsequent pulses of electrical energy. A low energy current impulse damage mechanism at second breakdown initiation has also been observed. The experimental investigations were performed using 1N4148 diodes fabricated with various junction areas and a fixed diffusion depth. (auth)

**22559** ADAPTATION OF THE p-n JUNCTION BURNOUT MODEL TO CIRCUIT-ANALYSIS CODES. McMurray, L. R.; Kleiner, C. T. (North American Rockwell Corp., Anaheim, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 76-81(Dec 1972).

From Annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

Transient electrical pulses impressed upon a circuit containing semiconductors subject the semiconductors to a thermal transient. Potential burnout of the parts is of particular interest and concern. A model is presented which permits the calculation of the transient temperature throughout the semiconductor given the instantaneous power dissipation within the device. The basic technique is to mathematically partition the device by isothermal surfaces, and construct the corresponding RC circuit. Lateral dispersion of the heat (two dimensional heat flow) is included as part of the model. The model has been compared to theory and test. The model is simple and can easily be programmed as a subroutine and attached to existing TREE circuit analysis programs. This permits efficient calculations from the applied electrical pulse to the internal temperature of the semiconductor for prediction of burnout. A demonstration computer solution is shown, and the memory size and run times are given. (auth)

**22560** TERMINAL MODELING AND PHOTOCOMPENSATION OF COMPLEX MICROCIRCUITS. Pocock, D. N.; Krebs, M. G. (Northrop Corporate Labs., Hawthorne, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 86-93(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

Results are presented on generalized approaches to derive radiation-inclusive simplified models of linear and digital microcircuits. Application of the principle of superposition allows generation of a compact small-signal model of the linear microcircuit, with extension of the model to include large-signal saturation effects. The digital microcircuit model is the combination of current-voltage terminal networks with a logical decision function to represent the truth table of the device. A factor of 20 to 50 improvement in required computer time and storage was realized with the terminal models over detailed models, with no significant loss in the representation of key performance parameters or radiation vulnerability. The linear modeling technique suggests that photocompensation networks can be applied successfully at the terminals of the device. (auth)

**22561** MODELING IC's IN AN IONIZING RADIATION ENVIRONMENT WITH A TIME-VARYING WIENER MODEL. Chao, K. S. (Texas Tech. Univ., Lubbock); Liberty, S. R.; Seacat, R. H.; Chipman, M. A. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 94-95(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

The Wiener theory of modeling nonlinear systems is generalized to include time varying systems. With radiation effects in integrated circuits being considered as internal time varying effects, this generalized technique can be used to model an integrated circuit in a radiation environment. (auth)

**22562** RADIATION MODELS FOR DIGITAL INTEGRATED CIRCUITS. Greenbaum, J. R. (General Electric Co., Syracuse, NY); Horen, R.; Andrews, J. L.; Peden, J. C. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 96-102 (Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

The effort described had as its objective the development of new techniques to define simplified models of digital integrated circuits suitable for use with the SCEPTRE or similar computer programs. These models were required to account for normal electrical performance as well as performance in an environment of ionizing and/or neutron radiation. Techniques were established to derive models capable of representing both the radiation effects and the first order transient response of the microcircuits as system components for many different kinds of digital integrated circuits. A black-box approach was employed to achieve the desired results. (auth)

**22563** LUMPED-MODEL ANALYSIS OF SEMICONDUCTOR DEVICES USING THE NET-2 CIRCUIT/SYSTEM AND ANALYSIS PROGRAM. Raymond, J. P.; Krebs, M. G. (Northrop Corporate Labs., Hawthorne, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19, No. 6, 103-107(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

Capability of the NET-2 circuit/system computer program in semiconductor device analysis is presented. Semiconductor devices are described in terms of lumped model networks of user-selected complexity. The basic capability is illustrated through the calculation of electrical and radiation-induced transient response of diodes and transistors. Capability of NET-2 is demonstrated by the analysis of a junction-isolated TTL gate. The TTL gate model was derived by the interconnection of detailed lumped models of each of the transistor elements. Calculated electrical switching response and photoresponse accurately simulated observed results. (auth)

**22564** ANALYTICAL TECHNIQUE FOR THE DETERMINATION OF EQUIPMENT PROBABILITY OF SURVIVAL TO RADIATION STRESS. Young, L. S.; Vassallo, F. A.; Kleiner, C. T. (North American Rockwell Corp., Anaheim, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 108-114(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

Two analytical techniques (Monte Carlo and Small Sample Theory) are described which have been used to produce a survivability function, $P_s(R_s)$, for equipment subject to a radiation stress, $R_s$. The methods have been used for permanent damage due to neutron fluence and transient upset due to ionizing radiation. The methods are illustrated using a series regulator circuit. The techniques are sufficiently general such that they are applicable to a variety of environmental stresses. (auth)

**22565** BIPOLAR TRANSISTOR SCREENING METHODS FOR NEUTRON HARDNESS ASSURANCE. Blice, R. D.; Munarin, J. A.; Pease, R. L. (Naval Ammunition Depot, Crane, IN). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 115-120(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

A detailed bipolar transistor model has been developed to determine the dependence of post-irradiation electrical parameters on preirradiation electrical measurements and physical parameters. Some of the features of the model are the following: (a) postirradiation lifetimes vary with injection level; (b) electric fields in base and emitter regions increase the emitter efficiency and normal base transport factor; (c) collector resistance decreases when minority carriers are injected into the collector; (d) collector resistance decreases when the collector-base junction is reverse biased and the depletion region extends into the collector; (e) junction doping profiles are modeled as exponential-constant; (f) junction efficiency degrades as injection level increases; (g) base width varies with collector-base voltage; and (h) all parameters except emitter width and junction areas are determined from electrical measurements, and radiation damage constants are determined from postirradiation parameters. The radiation damage constants are utilized in calculating sensitivity parameters. The radiation damage constants are utilized in calculating sensitivity parameters for preirradiation parameters to be used for neutron hardness screening. A computer program varies selected preirradiation model parameters one at a time and the resulting change in an electrical parameter of interest at a specified neutron fluence is determined. The postirradiation performance of other devices of the same type at the same operating point and irradiation level can be predicted as follows: (1) Multiply the appropriate sensitivity parameter by the normalized deviation of each screening parameter from the corresponding reference unit value; (2) add the sum of these products to unity; and (3) multiply this quantity by the postirradiation electrical parameter of the reference unit. (auth)

**22566** PREVALENT ERROR SOURCES IN TRANSISTOR DELAY-TIME MEASUREMENTS. Sawyer, D. E. (National Bureau of Standards, Washington, DC). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 121-124 (Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

Measurements of bipolar transistor delay times are extensively employed to predict neutron vulnerability. Of the various possible delay times, phase delay is most commonly measured. Although this is the simplest delay measurement to implement, the measurement circuit may be quite susceptible to extraneous signal coupling at the measurement frequency and this can cause the accuracy to be severely degraded. A technique for minimizing this delay-time error has been developed. It employs simple, preferably non-reactive, but at least known, networks in place of the transistor. From the differences between the "delay times" measured on these known networks, the location and magnitude of the error sources in the circuit are found. This allows one to reduce greatly the effects of the error sources on all subsequent measurements. To confirm the theory of the error-correcting technique, RC networks with known delay times were assembled on transistor headers. For a particular bridge configuration, the uncorrected delay times measured were quite frequency dependent, but this dependence was removed by adding a correction term to the delay times. The correction term is obtained from measurements on the non-reactive networks and does not at all depend on the measured RC network delay times. The effects of error-sources are particularly severe when transistors with low or moderate $h_{fe}$ values are measured, as when measurements are made on transistors that have been degraded by subjecting them to neutron radiation. The delay time then observed may show significant frequency-dependence, but, as for the measurement described on the RC networks, this dependence is the signature of the measurement system rather than the transistor, and may be removed by adding an independently-obtained correction term. In the absence of this correction, erroneous conclusions may be reached as to the effects of the radiation on the devices under test. (auth)

**22567** NEUTRON HARDNESS ASSURANCE OF BIPOLAR TRANSISTORS BY COLLECTOR RESISTANCE DETERMINATION. Smith, D. M.; Hahn, L. A. (Texas Instruments Inc., Dallas). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 125-128(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

An approach to neutron hardness assurance in bipolar transistors is described, based on an observed high correlation of post-irradiation, saturated current gain with pre-irradiation collector resistance. Two experiments are described in which the correlation of post-irradiation gain is determined, first, with a set of structural parameters measured on auxiliary test patterns on the same chip with the subject transistor and, second, with electrical parameters measured at the terminals of the subject device. Results of these experiments suggest the feasibility of using collector resistance as a single hardness screening parameter. Implementation of this approach requires incorporation of an auxiliary resistor structure on each transistor chip and determination of the resistor value acceptance limit for the neutron fluence of interest. (auth)

**22568** HARDNESS ASSURANCE THROUGH SUPPLIER DATA MONITORING. Heaton, E. C. (North American Rockwell, Anaheim, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 129-134(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

The need for continuously evaluating the hardness of a component supplier's production is described and a method by which this evaluation may be performed is defined. The evaluation method, known as Supplier Data Monitoring, is described in detail and actual examples are given which demonstrate its utility as a hardness assurance tool. The Supplier Data Monitoring Program is oriented toward use on a production program for which hardness design confirmation has been performed on a previous R & D program. Its prime objective is to maintain the hardness of each production component. It is attempted to demonstrate how monitoring supplier component data achieves this objective through early detection of adverse hardness shifts at the component level. (auth)

**22569** AGING EFFECTS ON ELECTRICAL AND RADIATION CHARACTERISTICS OF DISCRETE SEMICONDUCTORS. Apodaca, L.; Hughes, G. E. (North American Rockwell Corp., Anaheim, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 135-140(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707–.

The effects of operating life on the electrical and radiation effects characteristics of several high reliability discrete semiconductor device types were investigated. Approximately 2400 parts consisting of five transistor types, two regular diode types and a zener diode type with operating ages ranging from 1.6 to 5.9 years were tested in this investigation. The devices tested included representative samples of both silicon and germanium materials as well as alloy junction, mesa and planar fabrication technology. No correlation was found between operating life and the direction or magnitude of changes in either the electrical or radiation characteristics of the sample populations investigated. (auth)

**22570** RADIATION ENVIRONMENTS OF OUTER-PLANET MISSIONS. Kase, P. G. (Martin Marietta Aerospace Denver). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 141-146(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972). See CONF-720707–.

The outer-planets spacecraft must contend with a variety of radiation environments during its lengthy mission in deep space. These environments include onboard nuclear emitters, such as radioisotope thermoelectric generators, and natural sources—Earth's Van Allen Belt, galactic cosmic radiation, solar flares, and a trapped radiation belt at Jupiter. The effects of mission and spacecraft parameters on the neutron and proton fluences that might cause permanent damage to the electronic devices from these sources are discussed. It is concluded that electronic systems will function satisfactorily during these missions provided that appropriate precautions are taken. (auth)

**22571** RADIATION SENSITIVITY OF SILICON IMAGING SENSORS ON MISSIONS TO THE OUTER PLANETS. Brucker, G. J. (Radio Corp. of America, Princeton, NJ); Cope, A. D. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 147-155(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707–.

An investigation of radiation damage mechanisms and the magnitude of their effects on the operating characteristics of imaging sensors utilizing a mosaic array of silicon diodes in a television pickup tube is reported. The effects produced by bombardment of bare-silicon-diode arrays or vidicon tubes with 85 kV x-rays, cobalt 60 gamma rays, 1 and 11 MeV electrons, 3 MeV and 142 MeV protons, and reactor neutrons are presented. Results show that the dark (reverse bias) current of a diode array increases less than a factor of 2 if the fluence level is less than $10^4$ rads of gamma radiation or $4 \times 10^{11}$ 1-MeV electrons/cm$^2$. For these same dose levels, the quantum efficiency increases rather than decreases. Continued bombardment in excess of these fluences decreases the quantum efficiency and increases the dark current. Electrons of 11 MeV were more damaging than 1 MeV electrons by a factor of 10 to 20 while protons of 3 MeV more effectively produced dark current increases and quantum efficiency degradation in silicon diode arrays than 1 MeV electrons by a factor of $10^5$ in fluence. Protons of 142 MeV were less effective than 3 MeV protons in producing the same effects by a factor of $10^2$ in fluence. Measurements of these degradation effects at 217 K indicated that the dark current is reduced by a factor of 200 to 500 relative to room-temperature values. The theoretical description of the quantum efficiency as a function of wavelength of incident light does not by itself completely explain the post-irradiation quantum efficiency of diode arrays. The change in dark current of the diode array after bombardment is consistent with the hypothesis that radiation-induced interface states at the silicon/silicon-dioxide interface are the causes of this change. Interference effects produced by radiation bombardment during the operation of the television tube are investigated and limiting fluxes of electrons and protons are presented. (auth)

**22572** EFFECTS OF PROTON IRRADIATION ON SEVERAL SPACECRAFT SCIENCE COMPONENTS. Parker, R. H. (Jet Propulsion Lab., Pasadena, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 156-159(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972). See CONF-720707–.

During the course of the TOPS (Thermoelectric Outer Planets Spacecraft) OPGT (Outer Planets Grand Tour) programs and MJS77 (Mariner Jupiter Saturn 1977), several models have been developed and used to analyze the radiation hazard to the spacecraft. During this time typical components found in space flight science instruments have been selected and, using very small sample sizes, tested to determine their capability to function properly before, after and, in some cases during, exposures to energy equivalenced levels predicted by the models. The series of proton irradiation tests included two 140 MeV exposures from the 600 MeV syncrocyclotron at the Space Radiation Effects Laboratory (SREL) 33 and 38 MeV exposures from the 50 MeV cyclotron at the UCLA Physics Department Cyclotron Laboratory, and 33 MeV exposures at UC Davis. A table of the items irradiated, the proton energy and fluence, and a brief comment is presented. (WHK)

**22573** PREPARATION OF A STANDARD TECHNIQUE FOR DETERMINATION OF NEUTRON EQUIVALENCE FOR BULK DAMAGE IN SILICON. Green, M. L.; Thatcher, R. K. (Battelle Columbus Labs., OH). (IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 200-208(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972). See CONF-720707–.

How a neutron energy (1 MeV) equivalence should be calculated and the limitations of its utility are defined. The differences in the 1-MeV equivalence obtained by using Messenger's expression for the damage curve is examined. An experiment was performed to verify the adequacy and utility of using 1-MeV equivalence units to compare different neutron spectra. It is shown that for fission spectra close to a bare reactor that 1-MeV equivalence provides a slight improvement in the correlation of data taken from devices irradiated at different reactors. However, this improvement in correlation did not extend to devices irradiated with 14 MeV neutrons. The devices irradiated in this experiment showed a fission/fusion fluence ratio for equal damage of about 1.7 rather than the expected value of 2.5. (auth)

**22574** ELECTRICAL PROPERTIES OF ELECTRON-IRRADIATED GaAs. Kalma, A. H.; Berger, R. A. (Gulf Radiation Tech., San Diego, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 209-214(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972). See CONF-720707–.

The electrical properties of electron-irradiated GaAs have been studied. A defect with an energy level located at $E_c - 0.15$ eV has been identified. It is likely an intrinsic defect as it is produced in all n-type materials. It removes carriers at a rate of 1.6 to 2.2 cm$^{-1}$ in 1-MeV irradiations and 4.5 to 5.9 cm$^{-1}$ in 30-MeV irradiations. It anneals between 200 and 300°C with an activation energy of 1.2 eV. Another defect with an energy level located at $\sim E_c - 0.02$ eV is also observed in Si-doped material. It removes carriers at a rate of 1.1 cm$^{-1}$ in 1-MeV irradiations and ~7.5 cm$^{-1}$ in 30-MeV irradiations. It anneals in the same 200 to 300°C stage as the first level. A defect with an energy level located at $E_v + 0.17$ eV is observed in Zn-doped material following 1-MeV and probably 30-MeV irradiations. It removes carriers at a rate of 2.7 cm$^{-1}$ in 1-MeV irradiations and ~6 cm$^{-1}$ in 30-MeV irradiations. It anneals in a stage between 150 and 200°C. A second defect level located at $E_v + 0.06$ eV is also observed following 30-MeV irradiations. It removes carriers at a rate of ~4.5 cm$^{-1}$. For heavier irradiations, annealing above 300°C becomes important, and the carrier concentration and the mobility do not anneal together as they do below 300°C in lower-fluence irradiations. (auth)

**22575** FAST-NEUTRON EFFECTS ON GaAsP SCHOTTKY BARRIER DIODES AND HALL EFFECT DEVICES. Neamen, D. A.; Grannemann, W. W. (Univ. of New Mexico, Albuquerque). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 215-219(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707–.

GaAsP Schottky barrier diodes and Hall effect devices were exposed to fast neutron radiation at room temperature at fluences ranging from $10^{13}$ neutrons cm$^{-2}$ (E > 10 keV) to $8.9 \times 10^{16}$ neutrons cm$^{-2}$ (E > 10 keV). The carrier removal rate for the n-type material with a nominal doping of $5 \times 10^{15}$ cm$^{-3}$ and irradiated at a fluence of $9.7 \times 10^{14}$ neutrons cm$^{-2}$ (E > 10 keV) was determined from the capacitance-voltage characteristics of the diodes and was found to range between 5 and 6 cm$^{-1}$. The change in conductivity of the GaAsP with neutron radiation measured on the Hall effect devices agrees very well with the diode measurements, while the change in effective carrier concentration appears to be slightly greater in the diodes than in the Hall devices. The Hall effect device measurements showed that the GaAsP material tends to become intrinsic after irradiation at high neutron fluence levels. The decrease in minority carrier lifetime after neutron irradiation was observed from the transient photocurrent response of the neutron-irradiated diodes generated by an ionizing X-ray pulse. Isochronal annealing of the neutron-irradiated diodes showed approximately a 40 percent recovery in carrier concentration over a wide temperature range starting at 225°C and continuing up to the maximum annealing temperature of 580°C. (auth)

**22576** TIN AS A VACANCY TRAP IN SILICON AT ROOM TEMPERATURE. Brelot, A. (Ecole Normale Superieure, Paris). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 220-223(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

Silicon samples which contain a high concentration of dispersed tin have been irradiated at 80°, 140°, or 300°K with 3 MeV electrons. The interaction of defects (vacancies and interstitials) with tin was studied by infrared absorption measurements. The tin-vacancy pair was found by monitoring the release of vacancies when the pair anneals near 460°K. Vacancies released from tin are then trapped on oxygen to form the oxygen-vacancy defect which is measured by the strength of the 835 $cm^{-1}$ line. Because vacancies are trapped at room temperature by tin atoms, tin aids in the separation of vacancy and interstitial associated defects in silicon. An absorption band at 935 $cm^{-1}$ produced independent of the tin concentration is attributed to silicon interstitials trapped by oxygen in Si. This interstitial defect is stable to 330°K. Applications to devices are suggested. (auth)

**22577** LOW-ENERGY ION-BOMBARDMENT EFFECTS IN $SiO_2$. McCaughan, D. V.; Murphy, V. T. (Bell Telephone Labs., Inc., Murray Hill, NJ). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 249-255(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

Data on annealing of degradation in MOS quality $SiO_2$ films on Si produced by low energy (<5 KeV) $Ar^+$ ion bombardment are presented. It is demonstrated that it is necessary to anneal bombarded films to 900°C to remove all degradation. A new model for ion-bombardment degradation of insulator films invoking ion neutralization at the surface followed by impurity ion transport to the insulator/semiconductor interface is described. (auth)

**22578** DEPENDENCE OF MOS-DEVICE RADIATION SENSITIVITY ON OXIDE IMPURITIES. Hughes, H. L. (Naval Research Lab., Washington, DC); Baxter, R. D.; Phillips, B. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 256-263(Dec 1972).

From annual conference on nuclear and space radiation effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

The role of various impurities in the thermally grown silicon dioxide films of metal-oxide-semiconductor (MOS) structures has been investigated. It has been determined that aluminum and sodium within such films strongly influence the radiation-sensitivity of the corresponding MOS devices. The results of the present investigation indicate that much of the radiation-induced positive space charge accumulated within the silicon dioxide films is directly related to the drift and accumulation of ions such as those of sodium. Ionizing radiation, as from cobalt-60 gamma rays, liberates sodium ions, which are bonded by coulombic forces to non-bridging oxygens, and consequently, the sodium ions drift in the applied gate fields. The space charge due to the accumulation of sodium near the silicon dioxide-silicon interface then causes a perturbation in the surface properties of the silicon. The insight afforded by the above model provides a basis for the fabrication of surface-controlled devices less sensitive to radiation, as well as for the fabrication of radiation dosimeters where the converse in radiation sensitivity is desired. Utilizing appropriate dopants in the silicon dioxide films the desired radiation hardening and dosimetry objectives can be realized. (auth)

**22579** EFFECTS OF IONIZING RADIATION ON VARIOUS CMOS INTEGRATED-CIRCUIT STRUCTURES. King, E. E.; Nelson, G. P.; Hughes, H. L. (Naval Research Lab., Washington, DC). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 264-270(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

Additional process controls which have been implemented by semiconductor manufacturers in order to produce low threshold voltage CMOS integrated circuits are shown to significantly improve the radiation hardness of such devices. In particular, this improvement is directly correlated with reduced concentrations of the sodium impurity which results in smaller threshold voltage shifts for the p-channel (negatively biased) transistors. Further, it has been shown that n-channel devices can be hardened by the technique of ion implantation on production line integrated circuits. Thus, digital CMOS devices hard to greater than a Mrad(Si) have been realized. (auth)

**22580** RADIATION-HARDENED COMPLEMENTARY MOS USING $SiO_2$ GATE INSULATORS. Peel, J. L.; Kinoshita, G. (North American Rockwell Corp., Anaheim, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 271-274(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

The results of a study in which commercially-proven metal-oxide-semiconductor (MOS) processes are modified to provide radiation-hardened complementary MOS (CMOS) circuits are reported. Typical silicon-dioxide ($SiO_2$) gate-insulator processes are used, in conjunction with chromium doping, to fabricate hardened MOS capacitors, n and p channel transistors, and CMOS inverter circuits. The resulting CMOS circuits exhibit excellent electrical and performance characteristics and stability, while accumulating more than $10^7$ rads(Si) ionizing-radiation dose, under worst-case conditions. Observable radiation effects are essentially independent of static bias and are minimum under normal, dynamic operating conditions. The approach is not only compatible with commercial $SiO_2$ processes but appears adaptable to dielectric-isolation, such as silicon-on-sapphire (SOS). Hence, the demonstrated technology represents a "breakthrough" in the development of cost-effective, stable CMOS devices for use in advanced military systems. (auth)

**22581** CMOS HARDENING TECHNIQUES. Schlesier, K. M.; Norris, P. E. (Radio Corp. of America, Princeton, NJ). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 275-281(Dec 1972).

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See CONF-720707-.

Complementary symmetry MOS circuits have high noise immunity and low power consumption which make them particularly suitable for military and space applications. A major drawback to their use is radiation sensitivity to accumulated fluences of radiation and also to prompt radiation bursts (transient effects). A significant degree of hardening against transient effects can be achieved by building the circuits in silicon-on-sapphire. This technology provides complete dielectric isolation and reduces photocurrents in the silicon. It is shown that each device type (N and P channel) must operate under both negative and positive gate bias. Therefore, to ensure hardening against an accumulated fluence of radiation, a dielectric which is hard under both polarities of gate bias should be used. Results are presented for CMOS circuits made with $Al_2O_3$ gate insulators. (auth)

**22582** DETERMINING THE ENERGY DISTRIBUTION OF PULSE RADIATION-INDUCED CHARGE IN MOS STRUCTURES FROM RAPID ANNEALING MEASUREMENTS. Simons, M. (Research Triangle Inst., Triangle Park, NC); Hughes, H. L. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 282-290(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

Activation energy distributions for the positive space charge induced in MOS structures by pulsed ionizing radiation have been calculated from short-term, isothermal annealing data. These distributions are compared for conventional thermal oxides and oxides implanted with aluminum or sodium ions. (auth)

**22583** RADIATION-RESISTANT MNOS MEMORIES. Wegener, H. A. R. (Sperry Rand Research Center, Sudbury, MA); Doig, M. B.; Marraffino, P.; Robinson, B. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 291-298 (Dec 1972).

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See CONF-720707-.

Three types of memory transistor structures were subjected to gamma, neutron and electron radiation. The survival of stored information as a function of total dose and dose rate was recorded, and in addition, the effect of radiation on the overall writing and storage characteristics of the devices was studied. The results indicate that the threshold voltage vs applied voltage characteristics of the transistors are essentially unchanged up to total doses of $10^8$ rads. A specific bit of stored information will survive $10^6$ rads. The expected insensitivity of stored information to photocurrents during high intensity radiation spikes was proved by experiment. (auth)

**22584** PERFORMANCE OF HARDENED P–MOS DEVICES IN SEVERE NEUTRON ENVIRONMENTS. Aubuchon, K. G. (Hughes Aircraft Co., Newport Beach, CA); Bereisa, J. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 299-304(Dec 1972).

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P-channel MOS devices with a hardened gate insulator have been irradiated to a combined dose of $2 \times 10^{16}$ n/cm$^2$ ($E > 1.5$ MeV) and $1 \times 10^8$ rads (Si). The resulting degradation in device characteristics is described and compared with that due to gamma radiation alone. Significant neutron-induced channel mobility degradation was observed, but the anticipated changes in source-drain punch-through voltage and body effect due to neutron-induced carrier removal were not observed until subsequent post-radiation annealing. After $1 \times 10^{16}$ n/cm$^2$ and $1 \times 10^8$ rads (Si), the test devices were still operational, with a 50% decrease in drain current and a 4V increase in threshold voltage. The extension of this technology to the fabrication of a 5 ampere power switch and a multiple NOR gate integrated circuit, both hardened to doses above $10^7$ rads (Si), is also described. (auth)

**22585** RELATIVE ROLES OF CHARGE ACCUMULATION AND INTERFACE STATES IN SURFACE DEGRADATION (NPN PLANAR TRANSISTORS). Sivo, L. L. (Boeing Co., Seattle). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 305-312(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707–.

The relative roles of the radiation-induced interface states and oxide charges on the surface degradation of NPN planar transistors have been determined by using gate controlled measurement techniques. Three main conclusions resulted. (1) In general, the new interface states are the more important factor in the surface degradation of NPN transistors with oxide properties similar to those existing in the present study as long as a strong inversion of the base surface is not developed which causes a "channel" between the emitter and base contact. Charge buildup would then become the primary factor if extensive channeling did develop; this primarily would occur at high doses. (2) Extensive "channeling", affecting the high current gain, did not fully develop in our NPN transistors up to very high doses; however, the possible existence of channeling in other different oxide preparations cannot be ruled out. (3) The nonuniform nature of the charge buildup and the charge of the interface states can contribute significantly to low-current gain degradation. (auth)

**22586** INVESTIGATION OF RADIATION-INDUCED INTERFACE STATES UTILIZING GATED-BIPOLAR AND MOS STRUCTURES. Sivo, L. L. (Boeing Co., Seattle); Hughes, H. L.; King, E. E. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 313-319(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707–.

The radiation dose dependence of the energy profile of the interface state density, $N_{FS}$ (E), has been monitored for the first time by using quasistatic MOS C-V techniques. The surprising result is that the radiation-induced increases in the interface state density are proportional to the pre-irradiation density regardless of the energy position in the band gap (away from the band edges) and in spite of the differences in the nature of the pre- and post-irradiation interface states. Both undoped and aluminum-implanted silicon dioxide films were used in the MOS devices investigated in this effort. Also, the dose dependence of the capture cross-section for carriers, $\sigma$, has been determined for the first time by combining quasistatic MOS capacitance measurements with gate-controlled $I_{EBO}$ measurements. Initial cross section values were consistent with those determined by different techniques, $\sim 6 \times 10^{-16}$ cm$^2$. Contrary to the results that have been reported by other workers, $\sigma$ was found to be relatively constant with respect to changes in $N_{FS}$. Consequently, the radiation-induced rise in the surface recombination velocity is interpreted as being primarily due to an increase in $N_{FS}$. (auth)

**22587** PERMANENT AND TRANSIENT RADIATION EFFECTS IN BARITT MICROWAVE OSCILLATORS. Chaffin, R. J. (Sandia Labs., Albuquerque, NM). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 325-327(Dec 1972).

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See CONF-720707–.

The BARITT (barrier injection transit time) microwave oscillator is a new two-terminal microwave negative resistance device. Its operation is similar to the IMPATT oscillator except that punch-through-injection (PTI) is utilized instead of avalanche injection. The use of PTI results in improved noise performance. The noise measure is on par with GUNN devices and 20 dB better than IMPATT devices. The BARITT is simple to fabricate (silicon technology) and may possibly replace GUNN oscillators as radar local oscillators or in other low power applications. The effects of neutron and transient x-ray radiation on the BARITT oscillator are studied experimentally and theoretically. (WHK)

**22588** TRANSIENT IONIZING RADIATION EFFECTS ON IMPATT DIODE OSCILLATORS. Borrego, J. M.; Gutmann, R. J.; Cottrell, P. E.; Ghandhi, S. K. (Rensselaer Polytechnic Inst., Troy, NY). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 328-334(Dec 1972).

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See CONF-720707–.

The performance of a variety of IMPATT diode oscillators has been measured under transient ionizing radiation conditions, and the results of a large signal model which agrees with experiment are presented. Five hundred milliwatt cw diode oscillators (silicon and gallium arsenide with various types of avalanching junctions) were exposed to 100 nanosecond pulses of 10 MeV electrons at dose rates between $2 \times 10^8$ and $8 \times 10^9$ rads/sec. With these oscillators, the RF power is reduced at increasing dose rates and is quenched entirely during the radiation pulse at a dose rate dependent upon the DC bias current (greater than $5 \times 10^9$ rads/sec for 500 mW oscillators in vacuum). With diodes open to air, oscillators in low Q cavities were quenched during the radiation pulse with a total dose of 500 rads. The results of a large signal theory including the effects of leakage current are presented that agree well with the RF power decrease during irradiation. (auth)

**22589** NEUTRON-IRRADIATION EFFECTS ON MICROWAVE TRANSISTOR AMPLIFIERS. Webb, J. G.; Chaffin, R. J. (Sandia Labs., Albuquerque, NM). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 340-343(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707–.

Studies are presented of neutron irradiation effects on microwave bipolar transistors in two applications—small signal, low noise amplifiers and large signal, power amplifiers. In both applications microwave transistors are found to be neutron tolerant. In the low noise case, the amplifier noise figure increases by less than 1 dB after a neutron fluence of $2 \times 10^{15}$ n/cm$^2$ ($E > 10$ keV). The observed degradation in noise figure is related both theoretically and experimentally to neutron-induced decreases in DC and low frequency current gain, and good agreement is found. In the power amplifier case, saturated output power and power gain decrease by 1.8 and 3 dB, respectively, after $2 \times 10^{15}$ n/cm$^2$. The change in saturated output power is related to increased high frequency $V_{ce}$(sat), while the decreased gain is due to decreased high frequency current gain. Neutron effects on these transistor parameters are calculated from the power output and gain data, and compared with radiation effects on these parameters at low frequencies. (auth)

**22590** CURRENT CROWDING IN HARDENED POWER TRANSISTORS. Clark, L. E.; George, W. L. (Motorola Semiconductor Products Div., Phoenix, AZ). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 344-346 (Dec 1972).

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See CONF-720707–.

One of the crucial design criteria for radiation-hardened power structures is the appropriate emitter width. Too small a width results in unacceptably low yield on large-area structures, while too great a width is inefficient because current crowding reduces the active area of the device. The theory of crowding in the active mode and in the saturated mode are reviewed, and some numbers for effective emitter widths based on parameters typifying neutron-hardened power transistors are derived. A comparison with theory is made by irradiating transistors with different stripe-widths but identical impurity profiles. The comparison shows that utilization of the appropriate design theory allows excellent correlation with experimental results and allows quantitative design of power devices to be operated in the high level gain falloff regime both before and after neutron irradiation. (WHK)

**22591** RADIATION-PRODUCED TRAPPING EFFECTS IN DEVICES. Oldham, W. G. (Univ. of California, Berkeley). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 347-354(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707–.

The effects of radiation-produced majority carrier traps in junction space-charge regions are reviewed. The nature of trapping states is discussed, and defect states in the upper half of the bandgap are shown to be dominant in p+n junctions. A number of experimental methods for determining trap parameters are examined, and the results of various experiments compared. Three important levels are found at energies 0.48, 0.38, and 0.2 eV below the conduction band edge. Best estimates of the electron capture cross sections are $2 \times 10^{-14}$, $4 \times 10^{-15}$, and $1 \times 10^{-19}$ cm$^2$ respectively. These levels give rise to frequency dependent small-signal device parameters in junction field-effect transistors, as well as time dependent parameters for large signals. Only very slight trapping effects are found in enhancement-mode MOS transistors; however the effects should be much larger in depletion-mode devices. Trapping effects restrict the application of variable capacitor diodes. (auth)

**22592** SHORT-TERM ANNEALING IN SILICON DEVICES FOLLOWING PULSED 14-MeV NEUTRON IRRADIATION. Srour, J. R.; Curtis, O. L. Jr. (Northrop Corporate Labs., Hawthorne, CA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 362-370(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707–.

A study of short-term annealing in 14-MeV neutron-irradiated silicon devices has been performed employing a dense-plasma-focus fusion neutron generator (typical fluences: 1 to $5 \times 10^{10}$ n/cm$^2$; pulsewidth ~100 nsec). Fusion-fission comparisons are made based on companion experiments performed at a Triga reactor and on fast-burst reactor data obtained by Gregory and Sander. For solar cells and bipolar transistors, 14-MeV annealing factors are observed to be larger than their fission counterparts at early times following irradiation. At 20 msec, the fusion-fission annealing-factor ratio has a value typically in the range from 1.3 to 1.4. The unstable damage ratio at this same time is ~1.7 for equal amounts of stable damage. Annealing data for 14-MeV neutron-irradiated solar cells are shown to correlate quite well with electron density. For transistors, the maximum fusion annealing factor observed is ~5 at ~100 μsec for both npn and pnp devices. A qualitative model, based on differing defect densities in fusion and fission disordered regions, is proposed to account for the data. Additionally, a method for estimating transient annealing behavior as a function of neutron energy is presented. (auth)

**22593** RADIATION CHARACTERISTICS AND MISSION CONSIDERATIONS IN LITHIUM-CONTAINING SOLAR CELLS. Faith, T. J. (Radio Corp. of America, Princeton, NJ). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 371-374 (Dec 1972).

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See CONF-720707–.

Empirical relations between post-irradiation photovoltaic parameters and lithium-donor density gradient have been derived for crucible-grown lithium-containing solar cells irradiated by 1 MeV electrons to fluences from $3 \times 10^{13}$ to $3 \times 10^{15}$ e/cm$^2$. Open-circuit voltage increases logarithmically with lithium gradient both immediately after irradiation and after completion of recovery. A particularly strong gradient dependence after recovery from $3 \times 10^{15}$ e/cm$^2$ indicates the need for high lithium gradients (>$5 \times 10^{18}$ cm$^{-4}$) to maintain satisfactory cell performance after heavy electron irradiation. These, together with previously reported results provide the basis for a mission compatibility analysis for crucible-grown lithium cells in an electron-dominated radiation environment. (auth)

**22594** BETA IRRADIATION OF SILICON JUNCTION DEVICES: EFFECTS ON DIFFUSION LENGTH. Olsen, L. C. (McDonnell Douglas Astronautics Co., Richland, WA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 375-381(Dec 1972).

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See CONF-720707–.

The effects of electron irradiation on the minority carrier diffusion length in silicon devices has been studied by utilizing $^{147}$Pm and $^{85}$Kr beta sources. The beta spectra of $^{147}$Pm and $^{85}$Kr are characterized by maximum beta-particle energies of 230 and 670 keV, respectively. Short-circuit current for Li-doped p$^+$n and n$^+$p cells has been measured while the devices are continually irradiated. All devices have approximately 2 Ω-cm bases. The minority carrier diffusion length of the base region was deduced from the calculated betavoltaic collection efficiency. Finally, the diffusion damage coefficient has been calculated for each case. $^{85}$Kr beta irradiated, Li-doped p$^+$n cells exhibit a much smaller damage rate for the first few months of testing than n$^+$p cells. After decreasing from approximately 100 to 40 μm, the minority carrier diffusion length for the Li-doped cells began increasing until after 1.5 years of irradiation, it exceeded the initial value. $^{147}$Pm beta-irradiated n$^+$p devices show only a small amount of radiation effects. For example, typical values obtained for the damage coefficient are initially $10^{-13}$ compared to $10^{-11}$ for $^{85}$Kr beta-irradiated n$^+$p cells. Values of approximately $10^{-7}$ have been previously reported for n$^+$p cells coupled to 0.5 MeV electrons. (auth)

**22595** NEUTRON DAMAGE IN GaAs LASER DIODES: AT AND ABOVE LASER THRESHOLD. Barnes, C. E. (Sandia Labs., Albuquerque, NM). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 382-385(Dec 1972).

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See CONF-720707–.

The effects of fast neutron damage on GaAs laser diodes have been examined with the following results: (1) Infrared photomicrographs of laser output for diodes operating above threshold at 300°K reveal that neutron irradiation does not have a significant effect on the near-field spatial distribution. (2) Neutron irradiation of a group of laser diodes of different cavity lengths demonstrates that the damage-induced increase in threshold current at 300°K is due primarily to a decrease in gain factor. The rate of decrease of the gain factor with neutron fluence agrees with that predicted by a previously determined damage constant. (3) Preliminary measurements of total light output as a function of diode current at 300°K and 76°K show that the lasers are much less sensitive to neutron damage at currents significantly above threshold. In fact, for some diodes the light output at 76°K increases at a given current with neutron irradiation for fluences as high as $3 \times 10^{14}$ n/cm$^2$. (auth)

**22596** GAMMA IRRADIATION AND ANNEALING EFFECTS IN NITROGEN-DOPED $GaAs_{1-x}P_x$ GREEN AND YELLOW LIGHT-EMITTING DIODES. Epstein, A. S. (Harry Diamond Labs., Washington, DC); Share, S.; Polimadei, R. A.; Herzog, A. H. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 386-390(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707–.

Irradiation of GaP (green) and $GaAs_{.1}P_{.9}$(yellow) light-emitting diodes from a $^{60}$Co source results in a decrease in quantum efficiency, peak spectral intensity, brightness and carrier lifetime of the respective devices. Damage constants expressed in terms of absorbed dose are $K\tau_0 = 4 \times 10^{-8}$ rad(Si)$^{-1}$ for the green diodes and $K\tau_0 = 3 \times 10^{-8}$ rads(Si)$^{-1}$ for the yellow diodes. Following isochronal annealing to 500°C the efficiency, lifetime, and peak spectral intensity recover to 75% of their respective initial values. Recovery is noted to start at 250°C. (auth)

**22597** RADIATION DAMAGE AND ANNEALING EFFECTS IN PHOTON-COUPLED ISOLATORS. Epstein, A. S.; Trimmer, P. A. (Harry Diamond Labs., Washington, DC). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 391-399 (Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707–.

Photon-coupled isolators with both photodiode and phototransistor detectors were irradiated to a total dose of $10^8$ rads

(Si) at a $^{60}$Co source and to a fluence of $3.7 \times 10^{13}$ n/cm$^2$ (E > 10 keV) at a TRIGA reactor. Damage constants for both the biased and unbiased cases were obtained. Decreases in the current transfer ratios at the highest dose were from 60 for the isolators using photodiodes to more than 10,000 for the isolators using phototransistors. No changes were noted in the isolation resistance or the capacitance. Rise and fall times decreased by about a factor of seven for the isolators using phototransistors. After irradiation isochronal annealing data was obtained on the recovery of the degraded parameters. (auth)

**22598** EFFECTS OF IONIZING RADIATION ON DIELECTRICALLY ISOLATED JUNCTION FIELD-EFFECT TRANSISTORS. Neamen, D.; Shedd, W.; Buchanan, B. (Air Force Cambridge Research Labs., Bedford, MA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 400-405 (Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707–.

Transient (electron) and total (gamma) ionizing radiation effects on dielectrically isolated junction field effect transistors (DIJFET's) are presented as a function of dielectric isolation configuration, dose, dose rate, and bias. Four different device structures of DIJFET's are studied. The three device types incorporating $p^+$ buried layers to separate the $SiO_2$ dielectric from the active n-type channel region are shown to be relatively immune to permanent effects induced by ionizing radiation up to total doses of $10^8$ rads (Si), whereas the device structure utilizing dielectric isolation by simply replacing the substrate junction with a silicon dioxide dielectric showed serious degradation above $10^5$ rads (Si). The DIJFET structures utilizing $p^+$ buried layers are characterized in a transient ionizing radiation environment up to $6 \times 10^9$ rads (Si)/sec and in a total ionizing environment up to $10^8$ rads (Si). The transient photocurrent response of the DIJFET was experimentally determined to be one-fourth that of a regular JFET with the same surface geometry. (auth)

**22599** ANOMALOUS PHOTOCURRENTS IN LOW-POWER EPITAXIAL TRANSISTORS. Gaillard, R.; Genre, R. (Univ. Claude Bernard, Lyon). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 406-413(Dec 1972).

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See CONF-720707–.

Additional experimental results concerning the anomalous photocurrent problem are given. Anomalous photocurrents were observed in various epitaxial NPN transistors for different operating modes and bias voltages. It is particularly shown that the devices switch on a stable I(V) characteristic that agrees closely with that given by the avalanche injection mode obtained experimentally with a fast rising high current pulse generator. The triggering mechanism is investigated and emitter injection is found to be a necessary condition. This experimental approach allows us to predict accurately the anomalous photocurrent value without radiation tests and seems to be quite useful in hardening studies. (auth)

**22600** NEUTRON-DAMAGE FAILURE RATES FOR LARGE POPULATIONS. Holmes, R. R.; Wilson, D. K.; Blair, R. R. (Bell Telephone Labs., Whippany, NJ). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 414-417 (Dec 1972).

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See CONF-720707–.

The distribution of damage produced by individual 14 MeV neutron events was investigated experimentally. The optical target of a silicon vidicon was studied. The results were used to establish limits on the probability of failure in large device populations. It was concluded that the damage margin required to allow for extra damaging events is less than 40%, with most systems requiring a margin of less than 15%. (auth)

## Miscellaneous Instruments

*Refer also to abstracts 22369, 22413, 22843, 22976, 23597, and 23876.*

**22601** (FRNC-TH-298) STUDY OF THE IMPACT OF FINE PARTICLES ON A PIEZOELECTRIC TARGET IN VIEW OF DETERMINING THEIR MASS AND CONCENTRATION. Chabre, A. (Aix-Marseilles Univ. (France)). 1972. 204p. (In French). Dep. NTIS (U. S. Sales Only) $12.25.

A piezoelectric device was developed in view of measuring the size and concentration of particles produced in the cloud generated by an underground nuclear explosion with the formation of a crater. The measurement procedure can also be adapted to measure the granulometry of any type of particle in a fluid suspension. In the calibration, the diameter and velocity of the particles were varied as well as the dimensions of the piezoelectric material used. The size and concentration of particles usually encountered in radioactive clouds, particularly those associated with large quantities of fallout at places geographically remote from the explosion were studied. These principal aspects were studied: aerodynamic problems concerning the carrying away of particles, the carrying device, and the trajectory of particles near to the target; the granulometry of particles used for the calibrations and the particle distributions; the impact of particles on the piezoelectric material in relation to the target composition and measuring equipment. Measurable signals were obtained for 5 $\mu$ particles having masses of the order of $3.10^{-10}$ grams ejected at velocities of about 210 m/s. (FR)

**22602** (INS-TH-74) NIMFAN, COOLING FAN FOR AEC NIM BIN. Inaba, S.; Mishina, M. (Tokyo Univ. (Japan). Inst. for Nuclear Study). 2 May 1972. 7p. NTIS (U. S. Sales Only).

A simple cooling fan, NIMFAN, was devised for the ventilation of US AEC NIM standard bins. It can be mounted on standard 19-in. racks. Dimensions of the chassis are 43 mm in height, 410 mm in width, and 213 mm in depth. The total weight is 3.2 kg. Three $^3/_4$-in. fans are attached to the chassis, and they provide air flow of about 90 l/s. Three indicator lamps and three fuses are attached on a front panel so that any electrical failure can be detected. A diagram of the electrical circuit and construction of the chassis are shown. (JA)

**22603** (JINR-P13-6924) PROBLEMS OF DESIGNING PULSE SHAPERS ON HIGH-STABILITY AMPLITUDES. Semenov, B. Yu.; Lomakin, O. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1971. 14p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

Transistor parameters for determining the error in shaping pulses of high-stability amplitudes are discussed. The experimental data on these parameters are reported. Recommendations concerning the choice of the type of transistor, its initial conditions, and the way of connecting are presented which are necessary in designing the pulse shapers of high-stability amplitudes. (auth)

**22604** (LRP-57/72) ANALOG REGISTER OF NONRECURRENT SIGNALS. Perotti, J. P. (Centre de Recherches en Physique des Plasmas, Lausanne (Switzerland)). Dec 1972. (In French). Dep. NTIS (U. S. Sales Only) $3.00.

A wave form digitizer is described which allows one to record wave forms by consecutively sampling the amplitude of the input signal at 10 ns intervals. The 200 samples are converted into digital numbers and stored in a memory. (auth)

**22605** (N-72-31459) ENERGETIC PARTICLES EXPERIMENT INSTRUMENTATION PACKAGING PROGRAM FOR IMP-F (EXPLORER 34) AND IMP-G (EXPLORER 41) NASA INTERPLANETARY MONITORING PLATFORM PROGRAM. Final Report, June 1965–June 1969. (Bell Telephone Labs., Inc., Murray Hill, N. J.). 1 Jul 1970. Contract NAS5-9102. 98p. (NASA-CR-122468). NTIS.

The package design and assembly techniques for the IMP-F and IMP-G space-physics experiments, provided for the NASA Interplanetary Monitoring Platform Program, are described. Thin-film, hybrid, integrated circuits used in these instruments to increase component density and reliability, and special procedures and precautions for the fabrication of space hardware are described. (auth)

**22606** (NIIAR-P-131) NEUTRON CHOPPER WITH THREE SYNCHRONOUSLY ROTATING ROTORS SUSPENDED IN A MAGNETIC FIELD. Kalebin, S. M.; Rukolaine, G. V.; Artamonov, V. S.; Nikol'skii, S. N.; Kocherygin, N. G.; Pelevin, G. A. (Scientific Research Atomic Reactor Inst., Melekess (USSR)). 1972. 16p. (In Russian). INIS.

A neutron chopper with three synchronously rotating rotors and suspended in a magnetic field is described, and its use in forming a pulsed neutron beam from the SM-2 reactor is elucidated. Formulas are presented as an aid in designing the magnetic rotor suspension, and the principles of operation and the tracking scheme for synchronization are included. (tr-auth)

**22607** (RDT-C-7-17-T(3-73)) PLATINUM RESISTANCE THERMOMETER. (Division of Reactor Development and Technology (AEC), Washington, D. C.). Mar 1973. 18p. RSO.

A standard prescribing requirements for platinum resistance thermometers for nuclear and associated applications is presented. (auth)

**22608** (TID-7586(Pt.2)) HIGH TEMPERATURE THERMOMETRY SEMINAR HELD OCTOBER 1–2, 1959 AT OAK RIDGE NATIONAL LABORATORY. Grimes, W. R.; Cuneo, D. R. (eds.) (Oak Ridge National Lab., Tenn.). Aug 1960. 50p. Dep. NTIS $4.50.

Declassified 29 Mar 1973.

**22609** CONTINUOUS OXYGEN MONITORING OF LIQUID METALS. Minushkin, B.; Kissel, G.; Salzano, F. J. (to United States Atomic Energy Commission). U. S. Patent 3,711,394. 16 Jan 1973. Filed date 29 Oct 1970. 4p.

An electrode assembly for use in measuring the oxygen content of liquid sodium consisting of a solid body of electrolytic material for immersion in the sodium is described. The active electrode is oxygen or a gas containing oxygen circulated directly in contact with the inner coated surface of the body. (Official Gazette)

# ISOTOPE AND RADIATION SOURCE TECHNOLOGY

## Isotope Separation (Industrial)

*Refer also to abstract 22226.*

**22610** (K-OA-1726) $^{13}$C UNIT PRODUCT COSTS. Roberts, D. J. (Oak Ridge Gaseous Diffusion Plant, Tenn.). 16 May 1969. Contract W-7405-eng-26. 20p. Dep. NTIS.

The product cost study for the COCO process, the enrichment of $^{13}$C by repeated exchange between CO gas and an aqueous cuprous-ammonium chloride-CO complex, was completed. The investigation was conducted under the same considerations and limitations as the earlier cost studies. A summary of unit product costs at 90% enrichment for all the processes surveyed and the equipment and cost breakdown sheets for the COCO process are included. The COCO results are comparable with the CO distillation costs at low and intermediate production rates. The costs are consistently higher than CYANEX, however, due to the lower separation factor and the higher equipment cost associated with corrosive environments. (auth)

**22611** (PNCT-841-72-17) INFLUENCE OF A LIGHT GAS ON THE CENTRIFUGAL SEPARATION OF THE URANIUM ISOTOPES. Kai, T.; Tamai, K. (Power Reactor and Nuclear Fuel Development Corp., Tokai (Japan)). Jul 1972. 29p. NTIS (U. S. Sales Only).

The influence of a light gas on the centrifugal separation of uranium isotopes must be taken into account when the leakage of the gas or the atmosphere are inevitable. The design of a cascade of centrifuges will be affected by the influence of leakages on the centrifugal separation. First, the influence of a light gas on the maximum separative power is examined. Second the equation for isotope separation containing a light gas is obtained from the Hirschfelder's diffusion equations. The equations for the shape of the flow of gases are derived from the equation of motion by using the simple model that there are upflow and downflow throughout the centrifuge. Equations are also derived for the other model that the gases flow in two concentric thin streams. The results of the considerations and the calculations show that the influence of a light gas is negligibly small if the ratio of the light gas is low but the influence increases rapidly if the ratio becomes high. (auth)

**22612** SULZER RECTIFYING PLANTS FOR ENRICHING HEAVY WATER. Zmasek, R. (Winterthur Engineering Works Div., Switzerland). Sulzer Tech. Rev.; No. Nuclex 72, 46-54 (1972).

For some 20 years Sulzer has been designing rectifying plants for separating $H_2O$ and $D_2O$. Typical plants recently installed for the final enrichment stage in heavy water production facilities and for reconcentration of diluted heavy water in nuclear power stations are described. (auth)

**22613** CENTRIFUGE DEVICE. Manach, J. L.; Paris, F. (to Commissariat a l'Energie Atomique). French Patent 2,123,669. 15 Sep 1972. Filed date 27 Jan 1971. 8p. (In French).

A centrifuge device for the separation of two gaseous substances having slightly different densities (particularly U isotopes from $UF_6$) is presented. In this device, a bowl rotates about a vertical axis in a fixed enclosure. Bearings are provided at each end of the bowl, and the rotation occurs about these bearings. A system is provided for depressurizing the space between the bowl and the internal wall of the enclosure. The system is also provided with means for setting up a thermal gradient in this space around the bowl. The depressurization is accomplished with a molecular pump positioned at the same level as the ends of the bearings. This pump possesses a nonrotating part fixed to the enclosure and having a surface provided with helical grooves. It also possesses a rotating part functioning in conjunction with the fixed part and connected to the bowl. (FR)

**22614** ESTIMATES OF WESTERN EUROPE'S LONG-TERM ENRICHED URANIUM REQUIREMENT. Venditti, P. (CNEN, Rome). Com. Naz. Energ. Nucl., Notiz.; 18: No. 12, 31-38(Dec 1972). (In Italian).

After a brief discussion of the current European activities and projects in the enrichment sector, forecasts are made of the long-term enriched uranium requirements of the countries of Western Europe. (auth)

**22615** MINIATURE VERSION OF A CALUTRON ION SOURCE (8 May 1969) (Engineering Materials). (Oak Ridge National Lab., TN). (CAPE-2314).

A calutron outfitted with a new source and collector designed to handle milligram quantities of charge material is described. Small charges may be processed with normal efficiencies with only comparatively minor equipment changes. Results of separating milligram quantities of feed material in the calutron were favorable if not entirely consistent. Although the process efficiencies varied over a wide range, all separations were acceptable and further experimentation will undoubtedly yield more consistent results. Several enriched samples of uranium that were collected and assayed indicated that this new system is capable of separating material with considerably higher isotopic purity than would be expected from regular calutron separations. (RCK)

## Isotopic Power Sources

*Refer also to abstracts 22621 and 24219.*

**22616** (LA-5160-MS) DATA SHEETS FOR PPO RADIOISOTOPIC FUEL. Keenan, T. K.; Kent, R. A.; Mulford, R. N. R.; Shupe, M. W. (Los Alamos Scientific Lab., N. Mex.). Feb 1973. Contract W-7405-eng-36. 11p. Dep. NTIS $3.00.

PPO is the acronym for Pure Plutonium Oxide. The thermal energy of this fuel results from the radioactive decay of $^{238}$Pu and this energy is converted into usable electric power for space probe or other applications. The basic fuel module associated with the current MHW heat source is a PPO sphere 1.465 ± 0.015 in. diam and containing 100 ± 2 thermal watts. The spheres are individually encapsulated and then assembled into geometric arrays to form the working heat source. Certain properties of $PuO_2$ with emphasis on behavior at the proposed operational conditions are listed. Since many of the desired properties are still being determined, this document is preliminary in nature and will be revised periodically. LASL has the responsibility for fuel form development and characterization. Mound Laboratory, operated by the Monsanto Research Corporation (MRC), has the responsibility for production of spheres. Characterization studies will be carried out on material representative of that produced at MRC when deemed necessary. (auth)

**22617** MARKET STUDY OF POSSIBLE USES OF A RADIONUCLIDE BATTERY WITH DYNAMIC ENERGY CONVERTER. Kipp, P. R. (Gesellschaft fuer Kernenergieverwertung in Schiffbau und Schiffahrt mbH, Feesthacht, Ger.). Erdoel-Erdgas Z.; 88: No. 4, 139-147(Apr 1972). (In German). (GKSS-72-E-9).

In many cases, the energy supply is the limiting factor for oceanographic systems and missions. To ensure that future activity is not restricted by insufficiencies of conventional energy supply systems, it is necessary to develop systems which use novel energy sources. In accordance with this demand, a nuclear system of energy supply, derived from a conceptional study, is presented in four variations with different converter units. To establish quantitatively the demand situation for such a system, a market study was first conducted. Findings of the questionnaires are reported graphically and are analyzed. (tr-auth)

## Radiation Sources

*Refer also to abstracts 22432, 23600, and 24209.*

**22618** (CONF-710847-, pp 381-390) CALIBRATION BUILDING AT STUDSVIK. Widell, C.-O. (Aktiebolaget Atomenergi, Studsvik, Sweden). 1971. (In Swedish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

A special building has been provided for the calibration of radiation protection instruments and other radiation detectors. The building is situated far from other buildings in order not to be disturbed by other radioactive sources and not to disturb work in low background in other parts of the site. The main building material is wood. There are several radioactive sources placed in a shielded store in the floor of the building. The sources are pneumatically operated and the operator is shielded by a concrete wall with lead shields and lead-glass windows. The sources consist of cesium and cobalt ranging from 0.01 mCi to 100 Ci. A 2 Ci PuBe source is used for neutron calibrations. The sources can be used either in a fixed position or moving on a car. For lower energies an x-ray unit is used. (auth)

**22619** (JAERI-M-5007) SIMPLE COMPUTER PROGRAM FOR ACTIVITY CALENDAR OF STANDARD SOURCES. Okashita, H. (Japan Atomic Energy Research Inst., Tokyo). Oct 1972. 10p. NTIS (U. S. Sales Only).

A computer program in FORTRAN IV is presented for the activity calendar of standard (calibrated) sources. This calendar lists the activities of the relevant $\gamma$-rays day after day with the self-attenuation and branching ratio corrections. Uncertainty of the evaluated activities is also given. (auth)

**22620** TOTAL-BODY NEUTRON ACTIVATION FACILITY EMPLOYING PORTABLE ($\alpha$,n) SOURCES DEVELOPED FOR MEDICAL RESEARCH. Cohn, S. H.; Shukla, K. K.; Dombrowski, C. S.; Fairchild, R. B. (Brookhaven National Lab., Upton, NY). pp 605-615 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425–.

Developments in total-body neutron activation analysis (TBNAA) have been directed towards developing a uniform neutron fluence throughout the body, and reducing the absorbed dose to the patient. To date, all the medical research performed with TBNAA has been carried out with cyclotrons and neutron generators designed for research in physics. A new TBNAA facility has been designed and constructed at Brookhaven National Laboratory. The neutron activation system, employing portable ($\alpha$,n) sources, was designed specifically for use in medical research. The latest advances in TBNAA are incorporated in the system. Fourteen encapsulated $^{238}$Pu–Be sources, each 50 Ci, may be positioned along the midline, both above and below the length of the supine patient, to provide a "broad-beam" source of 5-MeV neutrons. The bilateral irradiation improves substantially the irradiation geometry. The sources are stored underground when the facility is not in use, and can be quickly positioned by a mechanical system to pre-determined positions. Moderation of the neutrons is accomplished with a polyethylene shield, closely fit to the patient, which maximizes the uniformity of the flux density. The reproducibility of the neutron output, the ease of operating the system, and the reduction in dose to the subject, make this TBNA system attractive. The absorbed dose per activation is less than 200 mrem, with a quality factor of 10. Applications of TBNAA are numerous and varied, and are increasing rapidly. Total-body Ca measurement has been used in a study of long-term therapy of osteoporosis with the hormone calcitonin. The Ca disorders in uraemia, endocrine dysfunction and disuse osteoporosis have also been investigated with Ca measurement. TBNAA should also be of considerable value in the studies of metabolic disorders involving sodium, chlorine and phosphorus. (auth)

**22621** STUDY OF TRANSURANIC ELEMENTS USED AS RADIATION AND ENERGY SOURCES. Keller, O. L. (Oak Ridge National Lab., TN). Energ. Nucl. (Paris); 14: No. 5, 361-373(Oct 1972). (In French).

The predictions concerning the production of transuranic elements in nuclear reactors necessitates research into their properties. Such research is aimed at determining the most appropriate uses for these elements. The most detailed research currently undertaken involves the isotopes of elements which appear promising as radiation and heat sources, e.g., $^{252}$Cf, $^{244}$Cm, $^{242}$Cm, $^{241}$Am, and $^{238}$Pu. Some examples of applications already undertaken or being undertaken are presented: $^{252}$Cf for underwater mineral prospecting, and for analyzing the atmosphere at the surface of Venus; and $^{238}$Pu as an energy source in the Apollo lunar program. (FR)

## *Design and Fabrication*

**22622** (AD-749856) HIGH FLUX ELECTRON IRRADIATIONS. Bouthillette, L. O.; Lowe, L. F. (Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.). 26 Jun 1972. 13p. (AFCRL-72-398; AFCRL-PSRP-499). NTIS.

Experimental techniques were developed for achieving high-flux, high-energy (1.5 MeV) electron irradiations in conjunction with radiation effects studies. Using these techniques a system was designed and fabricated which allowed irradiations to be carried out at a flux of $4 \times 10^{14}$ electron/cm$^2$/s on a routine basis. These flux levels allowed fluences of $10 \times 10^{18}$ electron/cm$^2$ to be achieved in a one-day irradiation. (auth)

**22623** (AE-462) ELECTRODEPOSITION OF "POINT" Cu $^{125}$I ROENTGEN SOURCES. Beronius, P.; Johansson, B.; Soeremark, R. (Aktiebolaget Atomenergi, Studsvik (Sweden)). 1972. 11p. Dep. NTIS (U. S. Sales Only).

Radioiodide was anodically deposited at room temperature on the semi-spherical end face of a 0.5 mm diameter copper wire using an electrolytic cell. The electrolyte consisted of a 2 ml aqueous solution of $4 \times 10^{-4}$ M sodium radioiodide (1750 mCi $^{125}$I$^-$) free of reducing agents and with a pH of 9.0. By using a constant current of 0.6 $\mu$A, 90% of the iodide content of the solution, corresponding to 1600 mCi of $^{125}$I, was deposited as copper radioiodide on the anode surface after electrolysis for 4.5 days. The deposit formed under these conditions was smooth and adherent. (auth)

**22624** DEVICE GENERATING A REFERENCE BEAM OF PENETRATING RADIATION. Guiho, J. P. (to Commissariat a l'Energie Atomique). French Patent 2,116,201. 13 Jul 1972. Filed date 9 Oct 1970. 14p. (In French).

A device for generating a reference beam of penetrating radiation (x or $\gamma$ rays) having well defined characteristics is presented. The generator is provided with an enclosure in which a rectilinear tunnel and a rectilinear canal are positioned. They are aligned. An intense small cross section and monoenergetic source is provided and positioned axially between the tunnel and the canal. A collimator, which is coaxial with the canal and in the form of a series of disks composed of a heavy material and pierced by holes, which are aligned along the axis of the canal, defines together with the source, a cone centered about the source. The disks are joined along their peripheries by a heavy material intended to trap the scattered radiation. The presence of the tunnel sensibly reduces the intensity of the radiation passing through the successive holes of the collimator after a backscattering which reduces the energy of the radiation; in reality, this scattering is much smaller with the gas atoms of the passage (air in general) than when the atoms of the solid wall are involved. (FR)

**22625** RADIATSIONNAYA TEKHNIKA. Vypusk 2. (Radiation Technology. Number 2). Shtan, A. S. (ed.). Mowcow; Atomizdat (1968). 280p.

Experimental and theoretical investigations are described in connection with nuclear-physical bases of radiation technology, radiation measurement, isotopic thermoelectric generators, industrial radiochemical processes, and equipment for irradiation. Beta backscatter thickness gages, and apparatus for radiology, gamma therapeutic work, and x-ray diagnostics are described. Some attention is given to neutron generators, neutron activation, and neutron-absorption analyses. (tr-auth)

## *Industrial Uses*

*Refer also to abstracts 22424 and 22527.*

**22626** (CONF-710847-, pp 371-380) RADIOACTIVELY LABELED IDENTIFICATION CARDS. Pettersson, B. G. (Statens Stralskyddsinstitut, Stockholm). 1971. (In Swedish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

The increasing use of false documents has necessitated more strict routines for the identity verification in banks. An identification card judged by banks and police authorities to meet high requirements on inherent security against falsifying is described. The radioactive labeling introduced to render falsification more difficult is presented together with an account of functional demands on the labelling. From the radiation protection point of view the card must be totally harmless to carry and use for individual persons handling it ($\beta$ radiation). The distribution of cards to a large number of people must not imply an unduly large contribution to the dose to the whole population offsetting the benefit gained by labeling (bremsstrahlung). Both theoretical calculations and experimental dose measurements were used to form a basis for dose estimations. The result of the examinations is an approved identification card labeled in a special way with not more than 1 $\mu$Ci $^{147}$Pm. (auth)

**22627** GEOMETRY CONTROL OF ETCHED NUCLEAR PARTICLE TRACKS. Fleischer, R. L.; Price, P. B.; Bostick, E. E.; Holub, F. F. (to General Electric Co.). U. S. Patent 3,713,921. 30 Jan 1973. Filed date 1 Apr 1971. 6p.

A process is described for making holes of reduced taper in a solid containing tracks of radiation damaged material. The solid is contacted with an etchant containing a surfactant. The product is useful as a filter. (Official Gazette)

**22628** SELF-LUMINOUS LIGHT-SOURCE AND ASSEMBLY THEREOF. Hand, A. (to Brandhurst Co. Ltd). British Patent 1,299,990. 13 Dec 1972. Filed date 7 Dec 1970. 4p.

The light source described consists of a sealed glass tube coated internally with a phosphor and containing tritium to excite the phosphor to luminescence. One or more transparent collars of synthetic polymer are fitted around the tube to serve as locating members within a light source assembly. The tube may be of any desired shape, and light sources may be assembled in a variety of ways in the light source assembly. The latter may have a light diffusive cover. (UK)

**22629** SEPARATING WANTED PARTICULATE MATERIAL FROM A MIXTURE OF WANTED AND UNWANTED PARTICULATE MATERIAL. Sumner, K.; Jenkinson, D. E. (to Coal Industry (Patents) Ltd.). British Patent 1,298,353. 29 Nov 1972. Filed date 22 Apr 1969. 4p.

The method described, which is particularly applicable to mineral and coal dressing, comprises passing the material along a path inclined to the vertical across a beam of high-energy radiation, also inclined to the vertical, measuring the intensity of the transmitted radiation, deriving electrical signals characteristic of the nature of the particles in response to the transmitted radiation, and feeding these signals to control means that react to signals of predetermined value to operate gas jets to deflect selected material from its path. The radiation beam may be divided into a number of streams each associated with a separate detecting means for deriving the electrical signals and separate jets. The jets are arranged to operate when either only wanted particles or only unwanted particles of material are detected, and at different velocities depending on whether the level of the electrical signal indicates that a wanted or unwanted particle is present. The radiation source may be an x-ray generator. (UK)

**22630** MIXTURE OF A RADIOACTIVE TRACER SUBSTANCE AND A PROPELLENT FOR MARKING DRILLING TOOLS FOR DEEP WELLS AND SIMILAR BOREHOLES. Becker, H. (to Farbwerke Hoechst, AG). U. S. Patent 3,716,426. 13 Feb 1973. Filed date 2 Jun 1969. 2p.

A mixture comprising a radioactive tracer, finely divided Al powder, and an alkali metal peroxide is described for deposit in cavities of deep well drill tools. The mixture explodes at contact with water to act as primer for an explosive such as ammonium picrate. The explosive, upon initiation, produces gas which drives the radioactive tracer from the cavity. The entire reaction is initiated when the drill tool wear exposes the embedded mixture thus signalling maximum allowable tool wear. (TFD)

**22631** PRESENTATION OF CAPRI. Puig, J. R. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 9-12(Jun 1972). (In French).

In 1967, a joint program between the CEA and outside industry led to the realization of CAPRI, a research laboratory concerned with the industrial applications of radiations. The credit made available to CAPRI, the industrial and economic policies, and the administrative policy were defined. The various installations are described. (FR)

**22632** IRRADIATION INDUSTRY IN FRANCE AND THROUGHOUT THE WORLD. Laizier, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 16-21(Jun 1972). (In French).

Industrial applications of radiation chemistry in various countries are discussed. The rapidly increasing economic importance of such applications is emphasized together with the mounting industrial competition occurring on a worldwide scale. (FR)

**22633** CONSTRUCTION OF CAPRI. Villa, A. (CEN, Fontenay-aux-Roses, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 23-25(Jun 1972). (In French).

The construction of CAPRI is described. CAPRI was constructed inside existing installations and consists of two irradiation units, an assembly of $^{60}$Co sources and a $^{60}$Co irradiator, Poseidon and Pagure, and a 3 kW Van de Graaff accelerator providing energies between 0.5 and 3 MeV. (FR)

**22634** COMPUTERIZED METHODS FOR EVALUATING DOSE RATES AND ESTABLISHING ISODOSE CHARTS. Blanchard, J. C. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 59-67(Jun 1972). (In French).

An example of the application of computer techniques in the field of irradiation studies is presented. Dose rates were investigated in the case of panoramic gamma irradiators. A program was used which utilized the physical laws of attenuation and absorption of gamma ray beams by matter and represented the extended source by a series of point sources. The nature of the target material was taken into consideration. A pilot plant for the radiovulcanization of latex is presented as an application. Studies of the internal volume of the Pagure irradiator are also presented. Isodose curves are given. Such curves are used to facilitate the exploitation of the results obtained. These curves are obtained on a plotter directly from the program. (FR)

**22635** TEXTILE AND PAPER FIBERS. Gaussens, G.; Lemaire, F.; Paoli, D. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 94-103(Jun 1972). (In French).

The industrial finishing of textiles using radiochemical grafting methods has become an industrial reality. Materials consisting of polyester/cotton mixtures are endowed with permanent pleating and dirt-resistant properties if the material is impregnated with a monomer and exposed to an electron beam. Pure hydrophilic polyester material is obtained by irradiating the material in the presence of a convenient monomer. The different methods of finishing textiles using radiochemical methods are reviewed together with the relevant physical parameters (radiation dose, dose rate, temperature and irradiation atmosphere) enabling the process to be controlled. Several industrial and pilot-scale processes are also described. (FR)

**22636** BUILDING MATERIALS. Gaussens, G.; Marchand, J.; Laroche, R. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 107-113(Jun 1972). (In French).

New building materials such as plastic-woods and plastic-concretes are being used more and more extensively because of the desirable properties which can be given to them by exposure to $\gamma$ radiation. A large range of products can be obtained depending upon the nature and proportion of the polymer added. As an example the polymer can be introduced into all or a proportion of the pores of wood (cellular cavities or channels) in order to obtain impregnated irradiated woods or it may be chemically bonded in the walls of the cavities to produce resinous woods. Drastic improvements over the characteristics of conventional materials are obtained: plastic-wood compounds are two to three times harder than untreated woods, their deformability is reduced by 50 to 70%, they are resistant to attack from insects and fungi. The compressive strength of polymer-concrete materials is 285% greater than that of the natural material, the modulus of elasticity is improved by 80%, the tensile strength is increased by 256% and the frost resistance is enhanced by 300%. (FR)

**22637** COMPUTERIZED HANDLING OF DOCUMENTATION RELEVANT TO CAPRI. Puig, J. R.; Stourm, R. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 53-58(Jun 1972). (In French).

A system for the storage of documentation concerning research and development in the fields of radiation processing, and the effects of radiation on matter is being operated at CAPRI and utilizes an IBM 360-91 computer. Modern documentation techniques enable documents to be retrieved rapidly with a high selectivity. (FR)

**22638** CALCULATED AND MEASURED DOSE DISTRIBUTION IN THE CONTAINERS OF A GAMMA IRRADIATION PLANT. Pallinger, E.; Naegelin, R. (Winterthur Engineering Works Div., Switzerland). Sulzer Tech. Rev.; No. Nuclex 72, 109-113 (1972).

Gamma irradiation installations are being employed for a variety of duties. Correct dosage of the irradiation is an essential requirement in them. Dose distribution in the containers of a plant of the small Unicell type can be determined both by calculation and measurement. Examples of these procedures are described and compared. (auth)

**22639** INDUSTRIALLY USED RADIATIONS AND THEIR EFFECTS. Gaussens, G. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 13-15(Jun 1972). (In French).

Sources in the form of electron accelerators or $\gamma$-emitting isotopes ($^{60}$Co or $^{137}$Cs) are used for radiation processing in industry. In all cases, the radiation is absorbed by the materials, its energy being transferred to the molecules. These molecules become excited or ionized and, as a result of their dissociation, rapidly give rise to free radicals. The chemical effects observed in irradiated materials are principally due to these radicals. The criteria enabling the specifications and the power of the sources best adapted to a given process are analyzed. The formulas and systems of units used in industrial radiation chemistry are given. (FR)

**22640** PAGURE AND POSEIDON. Laizier, J.; Lorin, M. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 30-38(Jun 1972). (In French).

Pagure and Poseidon are two $\gamma$ irradiation facilities of CAPRI. They are very different from one another and their respective irradiation powers (20,000 and 1,000,000 Ci of $^{60}$Co) fulfill complementary uses. Laboratory, pilot, and industrial scale irradiation requirements can be met. Both facilities offer easy access, observation, and handling conditions. (FR)

**22641** CAPRI LABORATORIES. Gaussens, G. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 46-48(Jun 1972). (In French).

CAPRI is located at the Saclay Nuclear Research Center. It thus benefits from the advantage of the proximity of specialized research laboratories. CAPRI is equipped with its own physics, chemistry, and macromolecular analysis laboratories together with a good basic infrastructure (vapor generator, liquid nitrogen, and industrial vacuum facilities). (FR)

**22642** CAPRI SERVICES. Laizier, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 68-69(Jun 1972). (In French).

CAPRI offers various types of service to private industry. Such services are provided rapidly with a maximum efficiency and economy. They include development services (utilization of radiochemical techniques), research facilities (principally in the field of polymers), the providing of irradiations for experiments and dosimetry. (FR)

**22643** CONTRACTS BETWEEN CAPRI AND INDUSTRY. Laizier, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 71-73(Jun 1972). (In French).

Several types of contracts between CAPRI and private industries are discussed. These contracts concern a wide program of collaboration ranging from research to joint development projects. Joint development projects provide attractive opportunities to private companies as they allow development projects to be carried out efficiently with a minimum financial risk. (FR)

**22644** PAINTS, VARNISHES, AND INKS. Gaussens, G.; Duchemin, J.; Blin, M. F.; Presson, C. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 74-84(Jun 1972). (In French).

The hardening of surfaces by irradiation has received considerable interest in recent years. Such methods possess notable economic and technical advantages over the conventional heat curing of surface coatings. Electron beam hardening processes are characterized by rapid cross-linking and copolymerization reactions occurring at room temperature. The most important parameters (radiation dose, dose rate, irradiation atmosphere, and electron energies) are reviewed. (FR)

**22645** RADIOVULCANIZATION OF RUBBER. Laizier, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 85-93(Jun 1972). (In French).

Radiation induced cross-linking of dry rubbers is not yet carried out on an industrial scale. This process will become economically attractive if the required doses can be reduced substantially. The irradiation of rubber latexes, on the contrary, appears very attractive since low doses are sufficient to induce a suitable degree of cross-linking. The process of radiation vulcanization of natural rubber latex was improved at CAPRI using a powerful electron beam radiation source. A production of 1 ton/hour was achieved. The irradiated latex and the resulting rubber sheets exhibit desirable characteristics. (FR)

**22646** MACROMOLECULAR RESEARCH AT CAPRI: SYNTHESIS OF RADIO-SETTING POLYMERS. Gaussens, G. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 104-106(Jun 1972). (In French).

The development of radio-setting polymers in the CAPRI laboratories has necessitated the synthesis of suitable chemical products. These polymers are characterized by their high reactivity. Ionizing radiations have the effect of inducing cross-linking processes and thus promoting the copolymerization of the final product. In spite of these characteristics, radio-setting polymers can also be used as conventional thermosetting polymers. (FR)

**22647** NEW PRODUCTS. II. Membranes. Marchand, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 126-128(Jun 1972). (In French).

Membranes have numerous applications but their development is somewhat retarded by their relatively poor performance. Improved membranes can be obtained from synthetic materials conveniently modified by grafting techniques. Irradiation techniques therefore may play a useful part in developing such membranes. (FR)

**22648** LIKELY APPLICATIONS OF INDUSTRIAL RADIOCHEMICAL TECHNIQUES DURING THE COMING DECADE. Laizier, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 129-133(Jun 1972). (In French).

In spite of the difficulties involved, an analysis of future trends in new products is extremely useful inasmuch as it can be used to orient research and development towards promising fields. Applications of radiation chemistry in many industrial fields are foreseen: manufacture, processing, and improvement of polymers, woods, textiles, coatings, papers, natural and synthetic leathers, and building materials. (FR)

**22649** FINANCIAL VIABILITY OF RADIO-PROCESSING PLANTS. Puig, J. R. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 134-137(Jun 1972). (In French).

The investments envisaged to ensure the operation of radiation processing plants are examined together with the expected production costs. Relatively large investments are envisaged leading to a drop in production costs to about 0.05P per kilo x megarad resulting from the introduction of mass production techniques. A decrease in production costs due to the reduced cost of irradiation installations (electron accelerators and $^{60}$Co $\gamma$-ray sources) is expected. The cases of contract work ensured by the irradiation installation and of continuous radiovulcanization are considered. (FR)

**22650** NEW PRODUCTS. I. SPECIAL PROBLEMS, MADE TO MEASURE PRODUCTS. Laizier, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 123-125(Jun 1972). (In French).

Two special applications of irradiation techniques are presented: the manufacture of ring seals having a very high degree of leak tightness; and the conferring of special properties to ophthalmic lenses. (FR)

**22651** VULCAIN AND PROMETHEE. Gaussens, G.; Jarry, E.; Pinet, P. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 39-45(Jun 1972). (In French).

CAPRI is equipped with a 3 MeV Van de Graaff accelerator (Vulcain) and a 300 keV accelerator (Promethee) having respectively a 1 mA or a 100 mA beam current. Vulcain provides a 40 cm wide beam at the window exit. The dose rate adjustment is ensured by controlling the scanning width, the electron energy, and the beam current. Samples are continuously introduced into the beam by means of 12 conveyor devices, whose velocities can be varied from 0.1 to 7 m/min. Promethee is an industrial accelerator whose power can reach 30 kW. It is equipped with a 1.80 meter scanner. This machine is installed in a large room well adapted to accommodate pilot scale devices, e.g., a device for surface processing. (FR)

**22652** INDUSTRIAL SAFETY OF THE CAPRI INSTALLATIONS. Vialettes, H. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 26-29(Jun 1972). (In French).

In the construction of CAPRI, particular attention was given to minimize the possibility of industrial accidents, special precautions being taken in the field of radioprotection against $\gamma$ rays, x-rays and accelerated electrons. The regulations concerning the safety standards are presented. The biological shielding is defined. The detection and safety systems installed are described together with the control procedures adopted for the running of the installation. The radiation level in the hall of CAPRI is below the minimum level legally envisaged. No working restrictions apply to personnel working in this hall. (FR)

# LIFE SCIENCES

## Radiation Effects on Biochemicals

*Refer also to abstracts 22664, 22675, and 22734.*

**22653** CROSS-LINKAGES IN HUMAN SERUM ALBUMIN POLYMERIZED BY GAMMA IRRADIATION IN SOLUTION. Zakrzewski, K.; Kloczewiak, M.; Hay, M. (Inst. of Nuclear Research, Warsaw). Radiat. Res.; 53: No. 1, 124-133(Jan 1973).

Human serum albumin in aqueous solution was irradiated with 7 Mrads of $^{60}$Co gamma rays in the presence of atmospheric oxygen, and analyzed by sedimentation velocity techniques. The radiation-polymerized material exhibited a continuous polydispersion, with the most abundant fraction between 1.3 and 1.7 × $10^6$ daltons, thus being equivalent to 19 to 25 monomeric albumin units. Monomeric albumin could not be detached by treatment with: 8 M urea, reduction and alkylation, and 1 M hydroxylamine—singly or in combination; nor was there a major decrease of sedimentation constants effected by these treatments. It was concluded that the following are not involved in cross linkages stabilizing the radiation-polymerized albumin: noncovalent bonds, disulfide bridges, simple ester, thioester, and imide bonds. (auth)

**22654** RADIOSENSITIZATION OF CATALASE IN THE PRESENCE OF SOME INHIBITORS IN VITRO. Olinescu, R. Rev. Roum. Biochim.; 9: No. 1, 61-68(1972).

Purified catalase was irradiated in the presence of different naturally occurring inhibitors (C, $B_2$, and $K_3$ vitamins and lactic and pyruvic acids) and their action on the activity of catalase was studied. Only lactic acid, among the used inhibitors, exerted a clear-cut radiosensitization effect on the activity of catalase. Lactic acid exhibited its effect in the physiological range and the radiosensitization increased with its concentration and in the presence of cupric ions. Lactic acid-induced radiosensitization of catalase was still evident when a hemolysate was irradiated and cupric ions enhanced this effect. The mechanism and the possibility that this radiosensitization could occur in vivo, in normal and pathological conditions are discussed. (auth)

**22655** STUDIES ON THE EFFECTS OF IRRADIATION ON PROTEIN. Changes in the optical rotation of protein produced by irradiation. Nisizawa, M. (Keio Univ., Tokyo). Keio Igaku; 49: No. 4, 281-286(Jul 1972). (In Japanese).

The solid albumin was irradiated by gamma rays of $^{60}$Co, and the effect on the radicals in the circumference of asymmetric carbon atoms was studied with polarimetry, and the after-effect in the lapse of time was studied. The irradiation doses were $10^3$ to $10^7$ rads. After 20 hrs, the irradiated albumin was dissolved in 2% of 6M of urea solution at 30°C, and then the optical rotation was measured. Saturated values of the specific rotation were increased depending on the irradiation doses. It is considered that changes in optical rotation with irradiation may be caused by changing of radicals (breaking or position changing) in the vicinity of the asymmetric carbon atoms. Irradiated albumin with the dose of $10^5$ rads at room temperature was stored in solid states for about 100 days. Dissolution in urea solution was made at various times after irradiation by the same methods as explained before. The saturated values of specific rotation decreased with the increase of stored times, but they stopped at certain value. It is considered that recovery may occur in the changed portion of radicals in the same way. (auth)

**22656** X-RAY INACTIVATION OF RIBONUCLEASE IN THE PRESENCE OF EDTA. Schuessler, H. (Erlangen Univ., Ger.). Int. J. Radiat. Biol.; 23: No. 2, 175-182(Feb 1973).

X irradiation of dilute solutions of ribonuclease carried out in the presence of EDTA resulted in different degrees of inactivation of the two catalytic functions. The dependence of the $D_{37}$ on the EDTA concentration gives evidence that the hydrolase function is protected by a scavenger effect, while the depolymerase function gets an additional protection, presumably by the prevention of a structural change. Gel-filtration studies showed that EDTA hinders the radiation-induced aggregation. (auth)

**22657** EFFECT OF $^{60}$Co-$\gamma$-RAYS ON THE INFRARED SPECTRA OF DNA. Karolyi, G.; Skapinyecz, J.; Somogyi, B.; Damjanovich, S. (Medical Univ., Budapest). Acta Biochim. Biophys. (Budapest); 7: No. 2, 179-185(1972).

High-polymer calf thymus DNA solutions were investigated by infrared spectroscopy between 800 and 1700 cm$^{-1}$. Cobalt-60 $\gamma$ irradiation ($\sim 10^4$ kR) caused only a minor alteration in the infrared spectra, mainly due to the damage of different bases. Higher irradiation doses ($\sim 10^5$ kR) increased the spectral changes at wavenumbers characteristic of certain bases. However those spectral parts characterizing the number of base-pairs remained practically unchanged after doses that produced degradation well detectable by viscosity measurements. (auth)

## Radiation Effects on Cells

*Refer also to abstract 22719.*

**22658** (NP-19684) EFFECT OF CYSTEAMINE ON THE SYNTHESIS OF NUCLEIC ACIDS (DNA AND m-RNA) AND PROTEINS OF DIFFERENT CELL TYPES. Boeluekbasi, E. (Cekmece Nuclear Research Center, Istanbul (Turkey)). 1972. 33p. Dep. NTIS (U. S. Sales Only) $3.75.

Thesis. Submitted to Istanbul Univ. (Turkey). Faculty of Science.

The effects of cysteamine on the synthesis of DNA, m-RNA, and protein of diverse cell types were investigated by the use of histological, tissue culture, and autoradiographic methods to study its radioprotective properties. It was concluded that cysteamine disturbed the metabolism of the cells under investigation at a considerable rate. (auth)

**22659** CELL INJURIES DUE TO EXTERNAL AND INTERNAL RADIATION SOURCES. Goutier, R. (Centre de l'Energie Nucleaire, Mol, Belgium). J. Belge Radiol.; 55: No. 2, 253-262 (1972). (In French)

Similar lesions, DNA chain breaks, seem to be at the origin of the short-term lethal effects of ionizing radiation from external sources, as well as of the lethal effects of incorporated radionuclides. The RBE of $\beta$ particles of incorporated $^3$H for lethal effect is close to one, since, for that particular effect, x rays and $^3$H $\beta$ particles both act by ionization, provided the $\beta$ dose is calculated as the dose received by DNA. Therefore, the maximal efficiency of a radionuclide is provided by carrier molecules which, such as thymidine, are specifically incorporated into DNA; any incorporation in another site of the cell results in a decreased killing efficiency of $^3$H. In the mutagenic effect of $^3$H and in the lethal as well as mutagenic effects of $^{14}$C and $^{32}$P, transmutation seems to play an important role not only by producing DNA chain breaks but also by producing changes in base pairing (point mutation). Lastly, DNA repair processes, well known after uV or x-irradiation, also seem to occur during the action of an incorporated radionuclide. (auth)

**22660** RADIOSENSITIZATION OF BLEOMYCIN ON LETHAL EFFECT OF MOUSE CANCER CELL IN VITRO. Matsuzawa, T.; Onozawa, M.; Morita, K.; Kakehi, M. (Aichi Cancer Center, Nagoya, Japan). Strahlentherapie; 144: No. 5, 614-617(Nov 1972).

In order to obtain cell lethality values of the combined effects on x ray and Bleomycin (BLM), mouse mammary carcinoma cells, FM3A, were pretreated with 25 $\mu$g/ml of BLM for 60 min. The survival curve of untreated (control) cell population has a broad shoulder (n = 6.5). A marked reduction in shoulder width (n = 4.2) was recognized on the survival curve of cells treated with BLM. The mean lethal dose ($D_0$) of the control cell population was 152 rad as compared to 121 rad in treated cell population i.e. a difference of 31 rad. These results reveal that BLM has a radiosensitizing effect on cell killing of mouse cancer cells in vitro. (auth)

**22661** EFFECT OF HYPOXIA ON THE GENERATION TIME OF MAMMALIAN CELLS. Koch, C. J.; Kruuv, J.; Frey, H. E. (Univ. of Waterloo, Ont.). Radiat. Res.; 53: No. 1, 43-48(Jan 1973).

Growth curves for Chinese hamster fibroblasts were determined for various partial pressures of oxygen. It is found that for oxygen tensions greater than 500 parts per million, growth is only minimally affected. At less than 500 parts per million, the number of cells increases exponentially for only a limited time and then remains constant. Viability, as determined by colony forming ability, remains high during this plateau phase even after 4 days under extremely hypoxic conditions. These studies were carried out to find out exactly how the growth rate of cells is altered at radiobiologically significant oxygen concentrations. (auth)

**22662** VARIATION IN RADIATION RESPONSE OF MAMMALIAN CELLS AS A FUNCTION OF OXYGEN TENSION. Koch, C. J.; Kruuv, J.; Frey, H. E. (Univ. of Waterloo, Ont.). Radiat. Res.; 53: No. 1, 33-42(Jan 1973).

Complete radiation survival curves for mammalian cells as a function of partial pressure of oxygen were obtained with considerable medium present. The results show an apparent decrease in extrapolation number (n) when irradiation is carried on during conditions of moderate hypoxia (5000 ppm oxygen) with the n value returning to the air level when the hypoxia becomes extreme. This phenomenon can be explained by radiochemical depletion of oxygen. At less than 25 ppM oxygen, the cells are not capable of sublethal repair, while at 200 ppM oxygen repair proceeds at almost the aerobic rate. (auth)

**22663** EFFECT OF DIETARY FATTY ACIDS AND TOCOPHEROL ON THE RADIOSENSITIVITY OF MAMMALIAN ERYTHROCYTES. Prince, E. W.; Little, J. B. (Harvard School of Public Health, Boston). Radiat. Res.; 53: No. 1, 49-64(Jan 1973).

Male weanling mice were placed on purified diets containing 20% safflower oil (highly unsaturated) or 20% coconut oil (full saturated) or on Purina Chow. Three months later, a 5% suspension of pooled blood was irradiated with 0 to 20 krads, and the percentage of hemolysis or potassium loss measured at various times thereafter. When the diets were supplemented with tocopherol (vitamin E), there were no significant differences in postirradiation hemolysis or potassium loss between cells from the two purified diets, despite considerable shifts in the relative amounts of unsaturated fatty acids in the cell membranes. When the two purified diets contained no tocopherol, however, the cells were not only more sensitive to hemolysis and potassium loss than cells from animals fed tocopherol, but the cells from the animals on the saturated fat diet were markedly more sensitive than those from animals on the unsaturated fat diet. This effect could be reversed by adding tocopherol (20 μg/g) to the diet 24 hr before obtaining the blood sample, or by preirradiation incubation of the cells in vitro with free tocopherol or with serum from animals fed a diet supplemented with tocopherol. Postirradiation incubation of the cells with free tocopherol had no effect on radiosensitivity. These results suggest that the presence of sufficient antioxidant, rather than the degree of saturation of dietary fats, may be the important factor in erythrocyte membrane radiosensitivity. Furthermore, it appears that a diet high in saturated fatty acids may not contain enough antioxidant to fulfill the erythrocyte membrane requirement. (auth)

**22664** REPAIR OF UV-INDUCED PYRIMIDINE DIMERS IN DROSOPHILA MELANOGASTER CELLS IN VITRO. Trosko, J. E.; Wilder, K. (Michigan State Univ., East Lansing). Contract AT(11-1)-1704. Genetics; 73: No. 2, 297-302(Feb 1973).

Tissue culture cells of Drosophila melanogaster were given various doses of uv light. The results indicate that Drosophila cells do have a dark-repair excision mechanism that is not sensitive to caffeine. Pyrimidine dimers were destroyed by photoreactivating illumination in these cells and this destruction probably represents monomerization of the pyrimidine dimers. (auth)

**22665** EFFECT OF IONIZING IRRADIATION ON HYALURONIC ACID PRODUCTION BY CULTURED HUMAN SYNOVIAL FIBROBLASTS. Yaron, M.; Yaron, I.; Allalouf, D. (Beilinson Hospital, Petah Tikva, Israel). Israel J. Med. Sci.; 8: No. 10, 1751-1754(Oct 1972).

Techniques for culturing and irradiating human fibroblasts are described. X radiation was administered in doses of 500, 1,000, and 2,000 R; gamma radiation was given in doses of 1,000, 2,000, and 3,000 R. Following irradiation the cells were trypsinized and counted and the hyaluronic acid in the culture media was measured. The tabulated results show that irradiated fibroblasts produced considerably more hyaluronic acid than the nonirradiated controls and the response appeared to be dose-dependent. There was a corresponding increase in glucose consumption. The significance of the results in relation to overproduction of acid mucopolysaccharides in inflammatory processes of the skin is discussed. (HLW)

**22666** PEDIGREE ANALYSIS OF GROWTH INHIBITION OF RAT HEPATOMA CELLS, CULB TC, AFTER GAMMA IRRADIATION. Sakka, M. (Tohoku Univ., Sendai); Katsuta, H.; Takaoka, T. Tohoku J. Exp. Med.; 106: No. 3, 275-284(Mar 1972). (In Japanese).

Cultured rat hepatoma cells were irradiated with 500 to 800 R of gamma rays and inhibition of cell growth was recorded on cinemicrograms. Analysis of constructed pedigrees of control and treated cells indicated that the usual type of frequency distribution of generation time did not apply to control cells, death after irradiation took place quite at random, natural death in control occurred more frequently in pedigrees with less divisions, and in some instances pedigrees with more divisions were more resistant to radioinduced death. (auth)

## Radiation Effects on Microorganisms

**22667** (RLO-2225-T-15-13) ASPECTS OF THE PHOTOBIOLOGY OF POTATO VIRUS X, ITS RNA, AND A HYBRID PARTICLE OF TMV PROTEIN-PVX-RNA. McCleary, L. O.; Gordon, M. P. (Washington Univ., Seattle (USA). Dept. of Biochemistry). 1971. Contract AT(45-1)-2225. 19p. Dep. NTIS.

The inactivation of potato virus X (PVX), free PVX-RNA, and a phenotypically mixed virus particle composed of PVX-RNA and U-1 TMV protein ($PVX_{RNA}$ : $TMV_{PRO}$) by ultraviolet radiation was studied at three wavelengths. Rate constants of inactivation and inactivation quantum yields were determined for irradiation in $H_2O$ and $D_2O$; the kinetic isotope effect for inactivation was calculated for the different particles. In addition, the visible light-dependent plant host mediated repair of ultraviolet damage known as photoreactivation following irradiation of PVX, PVX-RNA, and $PVX_{RNA}$ : $TMV_{PRO}$ at the three wavelengths in $H_2O$ and $D_2O$ was measured. These results are compared and the implications to the inactivation mechanism are discussed. It is concluded that the constraints imposed upon PVX-RNA by the capsomer protein of PVX are less than the corresponding constraints in the case of TMV. (auth)

**22668** GENETIC BASIS OF UV-RESISTANCE IN SALMONELLA. II. Uvr B-mutants of Salmonella Abony. Andreeva, I. V.; Kiryushkina, A. A.; Amerkhanova, A. M. (Inst. for Epidemiology and Microbiology, Moscow). Genetika; 8: No. 11, 117-122(Nov 1972). (In Russian).

Isolation and characterization of two independently isolated uv-sensitive mutants Salmonella abony are described. According to their phenotypic properties, these mutants are of Hcr$^-$ class with the alteration of the first step of excision repair. The genetic mapping of analyzed mutations shows their 3% cotransduction with gal operon. Thus the investigated mutations of Salmonella are probably located in a locus corresponding to uvr B locus of Escherichia coli. (auth)

**22669** ALLELISM TEST OF MUTANTS AFFECTING SENSITIVITY TO RADIATION IN YEAST OF DIFFERENT ORIGIN. Kozhina, T. N.; Zakharov, I. A. (Inst. of Nuclear Physics, Leningrad). Genetika; 8: No. 11, 171-173(Nov 1972). (In Russian).

The radiosensitive mutants of yeast Saccharomyces cerevisiae isolated in the Laboratory of Radiation Genetics of the Institute of Nuclear Physics are classified as the loci rad 2, rad 4, rad 5, and rad 15 in accordance with the accepted international nomenclature. (auth)

**22670** ULTRAVIOLET-INDUCED DELAY OF BUDDING IN SYNCHRONIZED YEAST CELLS. Johnson, R. G.; Walmsley, J. G.; Goodin, L. J.; Morrison, H. G. (Trent Univ., Peterborough, Ont.). Radiat. Res.; 53: No. 1, 134-142(Jan 1973).

Distributions of ultraviolet-induced budding delays in diploid yeast cells are presented for several ultraviolet doses. The results are fitted by a model that equates the budding delay to time required for repair of radiation-produced defects that inhibit budding. Photoreactivation and dark holding experiments suggest that the defects are pyrimidine dimers in the cell's DNA. (auth)

**22671** SELECTED PAPERS IN BIOCHEMISTRY. Volume 4. Radiation Biology of Microorganisms. Suzuki, K. (ed.). Baltimore; University Park Press (1971). 333p. $12.50.

Reprints of 25 selected papers on the radiation biology of microorganisms are presented. (ERB)

**22672** EFFECT OF $\gamma$ IRRADIATION AND HEATING ON PROTEOLYTIC ACTIVITY OF MEAT SAMPLES. Losty, T. (Univ. of Connecticut, Storrs); Roth, J. S.; Shults, G. J. Agr. Food Chem.; 21: No. 2, 275-277(1973).

Utilizing a $^{14}C$-labeled hemoglobin substrate, the total proteolytic activity of ground beef samples subjected to $\gamma$ irradiation and/or brief heating (blanching) was determined. Gamma irradiation alone, in increasing doses from 2 to 6 Mrad, destroys up to 75% of the proteolytic activity but is less effective than blanching, especially when the latter is carried out at 70°. A combination of irradiation at a dose of 4.5 to 5.2 Mrad plus blanching at 65 or 70° may be expected to destroy at least 95% of the proteolytic activity in beef. (auth)

**22673** UNEXPECTED LOCATION OF A GENE CONFERRING ABNORMAL RADIATION SENSITIVITY ON PHAGE T4. Maynard-Smith, S.; Symonds, N. (Sussex Univ., Brighton, Eng.). Nature (London); 241: No. 5389, 395-396(9 Feb 1973).

It is stated that three mutations have been characterized, each of which increases the radiation sensitivity of phage T4 by a factor of about two. Two of the corresponding genes had already been mapped, but the third (y) had not been mapped. This gene was located on the circular genetic map of phage T4. Unlike the first two which, as expected, map close to early genes involved in phage DNA synthesis, the y gene is surrounded by late genes that determine the structure and assembly of the phage head and tail. The y mutant was isolated from a phage stock that had been heavily mutagenized with $NH_2OH$ and then back-crossed with T4 wild type. It was concluded from the experimental work that the y gene lies between genes 24 and 25. The results are of interest for the following reasons: first, they have identified a new essential gene in phage T4 which, because it is implicated in radiation repair, is presumably involved in some aspect of phage DNA synthesis; and secondly, they suggest that the previously uncharted region of the T4 genome that lies between genes 24 and 25 represents a further region that contains genes involved in early functions. (UK)

**22674** STUDY OF THE UV EFFECT ON MS2 PHAGES. Karczag, A.; Ronto, G.; Tarjan, I. (Semmelweis Medical Univ., Budapest). Acta Biochim. Biophys. (Budapest); 7: No. 2, 173-177(1972).

The effect of $\lambda = 254$ nm uv light on the plaque forming activity of MS2 phages was examined. The dose-effect curve similar to that of the T7 phages is of the one hit type and, when seen from above, its shape is concave. An attempt was made to analyze the dose-effect curve with the radiation kinetic model developed for the T7 phages. The deviation of the dose-effect curve from that of the T7 phages was assumed to be brought about by the induction of different photoproducts of the DNA and RNA bases: upon the effect of uv irradiation uracil may undergo, besides dimerization, hydration, too. From the initial phase of the MS2 dose-effect curve and from the comparison of the T7 and MS2 dose-effect curves the probability of phage inactivation due to dimer formation and to hydration was determined and found to be about $2 \cdot 10^{-4}$ and $1 \cdot 10^{-4}$, respectively. The former value is similar to the probability obtained for T7 phages. (auth)

**22675** STRAND BREAKS IN DEOXYRIBONUCLEIC ACID OF THYMINE STARVED BACTERIA. Bhattacharjee, S. B.; Das, J. (Univ. of Rochester, NY). Int. J. Radiat. Biol.; 23: No. 2, 167-174(Feb 1973).

Thymine starvation of Escherichia coli B/r resulted in a decrease in single-strand molecular weight of DNA, as determined by sedimentation in alkaline sucrose gradient. This decrease could not be compensated by 60 min incubation in growth medium after thymine starvation. The strand breaks in DNA induced by x irradiation could not be repaired in growth medium in 60 min when the cells were prestarved of thymine. Thymine-starved cells also showed more strand breaks in DNA, at the same levels of survival, due to x irradiation than the cells that were not so starved. (auth)

**22676** INVOLVEMENT OF BACTERIOPHAGE T4 GENES IN RADIATION REPAIR. Maynard-Smith, S.; Symonds, N. (Sussex Univ., Brighton, Eng.). J. Mol. Biol.; 74: No. 1, 33(15 Feb 1973).

One interpretation of Ebisuzaki's (1966) observation that the functional survival of certain early phage T4 genes is identical in $\nu^+$ and $\nu$-infected cells is that the product of the early gene being studied is essential for the successful completion of excision repair (which is known to be mediated by the $\nu$ gene). An experiment designed to test this hypothesis is described, with results that fully support the idea. Assuming that this interpretation is valid, it became possible to determine the involvement in excision repair of a much wider range of early genes by establishing whether or not the $\nu$ allele affects their functional survival. In addition a comparable series of experiments was performed with phages carrying the uv-sensitive y mutation which is known to mediate a quite different type of repair in T4-infected cells. The results indicate that genes 1, 30, 42, 45 and 56 are involved in excision repair, but not genes 32, 41, 43 and 44. All these genes are however involved in y-mediated repair. It appears therefore that this latter repair system (which bears some resemblance to that controlled by the rec genes in bacteria) depends on normal phage DNA synthesis for its completion. However the repair synthesis following the excision of pyrimidine dimers in uv-irradiated T4 DNA seems distinct from normal DNA synthesis in that it does not involve certain of the early phage genes, and in particular does not utilize the DNA polymerase coded by gene 43. It is suggested that the polymerase activity associated with this repair synthesis is provided by the bacterial Kornberg polymerase pol I. (auth)

**22677** MAPPING OF A COMPLEX GENE LOCUS CODING FOR PART OF THE SACCHAROMYCES CEREVISIAE FATTY ACID SYNTHETASE MULTIENZYME COMPLEX. Burkl, G.; Castorph, H.; Schweizer, E. (Univ., Wuerzburg, Ger.). Mol. Gen. Genet.; 119: No. 4, 315-322(1972).

Using two different experimental approaches, uv induced mitotic recombination and meiotic segregation, a fatty acid synthetase gene locus has been mapped on chromosome Fragment V of the Saccharomyces cerevisiae genetic map. This locus has been tentatively designated as fas 1 AB since it is a complex locus coding for at least two different fatty acid synthetase component enzymes, namely the $\beta$-hydroxyacid dehydratase and the enoyl reductase. According to the meiotic segregation patterns obtained, fas 1 AB is 41.6 centimorgans from ura 1 and 35.7 centimorgans from trp 3. Furthermore, the same criteria of mitotic sectoring and meiotic segregation indicate that the second known fatty acid synthetase gene cluster in yeast is genetically unlinked to fas 1 AB or to any other of the known genetic loci on Fragment V. (auth)

**22678** CHANGED DOSE-RESPONSE IN SACCHAROMYCES AT DOSE RATES ABOVE $10^7$ RAD PER SEC. Averbeck, D.; Ebert, M. (Christie Hospital and Holt Radium Inst., Manchester, Eng.). Int. J. Radiat. Biol.; 23: No. 2, 151-156(Feb 1973).

The dose-response of a haploid wild-type Saccharomyces and its mutants $r_1^s$ and $r_2^s$ to electrons of a dose-rate of $1.2 \times 10^7$ rads/sec and 1 pulse per second was compared with that of dose-rates of $1.6 - 9.8 \times 10^9$ rads/sec and varying pulse frequencies in hypoxic conditions. Lower dose-rate exposures produced exponential, higher dose-rate exposures concave survival curves. Budding cells did not influence the shape of the survival curves. At the 10% survival level, all cells were 30% less sensitive at the lower than at the higher dose-rates. At lower survival levels the situation reverses. It was suggested that the change in sensitivity may be due to a fast healing process at the lower dose-rates and radical-radical interactions at higher dose-rates. (auth)

**22679** STUDIES ON THE MICROORGANISMS OF CEREAL GRAIN. Effect of Gamma-irradiation on the Storage of Maize and Milo. Watanabe, H. (Japan Atomic Energy Research Inst., Takasaki); Ito, H.; Shibabe, S.; Iizuka, H. Nippon Nogeikagaku Kaishi; 45: No. 11, 500-506(Nov 1971). (In Japanese)

Maize and milo (sorghum) imported from the USA were used as samples in order to investigate the effect of gamma irradiation on storage at 30°C in a polyethylene pouch. The species of molds propagated on the stored grains containing moisture of less than 16.0% were mainly the Aspergillus restrictus group and Aspergillus glaucus group. A. glaucus group and yeast-like organisms were prevalent on the stored grains containing 19.2% moisture. The yeast-like organism was radioresistant and its $D_{10}$ value was 0.18 Mrad. The number of the yeast-like organisms rapidly increased on the stored grains containing 19.2% moisture, but did not increase for one month on those stored at 10°C and on the grains containing moisture of less than 16.0%. The number of bacteria decreased with the storage time. By means of 0.6 Mrad irradiation, the number of molds was not increased for two months on the stored maize containing 13.0% moisture. On the milo containing 14.0% moisture, the number of molds was not increased for three months by means of 0.6 Mrad irradiation. (auth)

## Radiation Effects on Plants

**22680** MUTATION BREEDING OF KALANCHOE. Broertjes, C. (EURATOM-ITAL, Wageningen, Netherlands); Leffring, L. Euphytica; 21: 415-423(1972).

Freshly detached leaves of Kalanchoë cv. Annette and Josine were irradiated with x rays and then planted to root and to produce adventitious plantlets. The age of the leaf, the presence or absence of the petiole as well as the genotype proved to be important factors in the production of adventitious plantlets. In Kalanchoë only solid, non-chimeral mutants were observed, which indicates that the apex of the adventitious plantlets may originate from a single cell. This observation agrees with similar results in Achimenes, Saintpaulia, Streptocarpus, and other species, where only a very small fraction of the mutants consisted of chimeras. The mutations observed were changes in flower colour and size, time of flowering, type of inflorescence, leaf form, size and colour, plant habit and other directly visible characters. A few promising mutants, selected by commercial plant breeders, are being propagated and will be evaluated. (auth)

**22681** EARLY-DWARF MUTANT IN LINSEED INDUCED BY GAMMA RAYS. George, K. P.; Nayar, G. G. (Bhabha Atomic Research Centre, Trombay, India). Curr. Sci. (India); 42: No. 4, 137-138(20 Feb 1973).

Seeds of Linum usitatissimum were exposed to 25, 50, 75, and 100 kR of gamma radiation at a dose rate of 15.5 kR/min. In the $M_2$ generation four plants from the 50 kR group flowered 25 days earlier than controls. These plants were shorter than controls and their leaves were long, narrow, and sparse. The mean time of flowering was about 30 days earlier in the $M_3$, $M_4$, and $M_6$ generations than in the parent and the mean weight of 1000 seeds was greater than that of the parent. (HLW)

**22682** GENETIC ALTERATIONS AT THE MOLECULAR LEVEL IN X-RAY INDUCED AD-3B MUTANTS OF NEUROSPORA CRASSA. Malling, H. V.; De Serres, F. J. (Oak Ridge National Lab., TN). Radiat. Res.; 53: No. 1, 77-87(Jan 1973).

Attempts were made to identify at the molecular level the genetic alterations in x-ray induced ad-3B mutants of Neurospora crassa obtained in three separate experiments after doses of 710, 850, 1420, and 1700 R. Revertibility after treatment with nitrous acid (NA), N-methyl-N'-nitro-N-nitrosoguanidine (MNNG), methoxylamine (OMHA), and a monofunctional acridine mustard (ICR-170) was used to identify genetic alterations in the individual mutants. Base-pair transition mutants revert after treatment with NA and/or MNNG and/or OMHA. Base-pair insertion and deletion mutants revert after treatment with ICR-170 and are not usually revertible with the other three mutagens. A total of 135 ad-3B mutants were obtained after irradiation of heterokaryotic conidia from a biochemically marked, balanced heterokaryon. A total of 101 of these mutants could be tested for induction of revertants; the rest were too leaky or were aconidial. Among the mutants tested, the spectrum of genetic alterations induced by x rays in the wild-type strain was as follows: base-pair transitions, 42% (10% GC to AT, 32% AT to GC); base-pair insertion or deletions, 37%; mutants reverting only spontaneously, 15%; and nonrevertible mutants, 6%. (auth)

**22683** INFLUENCE OF ILLUMINATION ON POLYSOME FORMATION IN DARK-GROWN EUGLENA GRACILIS CULTURES. Heizmann, P. (Univ. de Lyon, Villeurbanne, France). Biochim. Biophys. Acta; 277: 149-160(Aug 1972). (In French).

Illumination of dark-grown Euglena with ultraviolet light results in a rapid formation of polysomes, even in conditions limiting rRNA synthesis. After return to dark of dark-grown cultures submitted to limited illumination, kinetic analysis of polysome-degradation suggests the existence of two polysome classes: photoactive polysomes that undergo rapid degradation and "photoinduced" polysomes, which are synthesized for some time in the dark. In the light of results obtained in different conditions, possible cellular activities of these polysomes are discussed. Polysome formation seems to result from synthesis of different mRNAs. Photoactive polysomes could correspond to continuously light-dependent mRNA synthesis. (auth)

**22684** EFFECT OF GAMMA RAYS ON SECALE CEREALE L. CELL ULTRASTRUCTURE. Ciobanu, I.; Tacina, F. Rev. Roum. Biol., Ser. Bot.; 16: No. 6, 391-396(1971). (In French).

Experiments were performed on rootlets obtained from the germination of some dry caryopses of diploid rye exposed to 5,000 to 25,000 $\gamma$ R to study the effect of ionizing radiation on cellular ultrastructure and dynamics. Observations were made by means of electron microscopy. As compared to the ultrastructure of nonirradiated normal cells, the ultrastructure of irradiated cells underwent changes proportional to the dose of radiation; e.g. with doses of 10,000 R ultrastructural alterations were evident; with doses of 25,000 R lysis phenomena occurred resulting in the destruction of the cytoplasm. Radiation induced changes in mitochondria and proplasts. The cytoplasm of cells exposed to doses of 15,000 R underwent a complex process of deterioration Exposure to doses of 25,000 R revealed a large amount of cytoplasm within the vacuoles and ribosomes and mitochondria in the process of lysis. The stroma of the irradiated cell chloroplast was poor in granular particles showing some empty spaces. Most specific, however, was dilation of tips, which come to look like small vesicles. (Rom. Sci. Abstr.)

**22685** EFFECT OF GAMMA IRRADIATION ON QUANTITATIVE CHANGES IN THE CARBOHYDRATE CONTENT OF GERMINATING PEAS. Frank, J.; Lendvai, Z. (Agricultural Research Inst., Iregszemcse, Hungary). Acta Agron. (Budapest); 20: No. 1-2, 123-127(1971).

A study was made of the effect of radiation on the ratio of starch to sugar-like carbohydrate in pea cotyledons in connection with the starting of germination. It was found that on the first day following irradiation the total carbohydrate content of the seed increased, while the quantity of soluble sugars decreased by 25%. This decrease was then followed by an immediate 10 to 20% increase, then on the 9th day the soluble carbohydrate fraction of plants approached and attained respectively in all radiation treatments the sugar level of untreated plants. At the critical point of germination, on the fifth or sixth day after water uptake the amylase-complex reacted to the radiation treatments with an increased hydrolyzing activity, as a result of which the dry matter related sugar content of treated seedlings exceeded by 2 to 8% that of the control. On the 9th day, on the other hand, carbohydrate percentage of treated seedlings was higher than that of the control only in the case of stimulating doses. (auth)

**22686** RADIATION APPLICATION FOR IMPROVEMENT OF PLANT BREEDING. Breeding Plants With High Nutrients. Tanaka, S. (Inst. of Radiation Breeding, Omiya, Japan). Radioisotopes (Tokyo); 21: No. 7, 456-462(Jul 1972). (In Japanese).

A review is presented of the use of radiation for mutation breeding of crop plants such as rice and barley for improved agricultural characteristics. A discussion is given of the use of radioinduced mutations for increasing nutritive value and yield of crops. Increased protein and oil content, disease resistance, and early maturity resulting from radiation treatment are also discussed. (HLW)

**22687** ULTRAVIOLET INDUCED MUTATIONS IN ASPERGILLUS CHEVALIERI (MANGIN). Nanda, G.; Nandi, P.; Mishra, A. K. (Bose Inst., Calcutta). Nucleus (Calcutta); 15: No. 1, 52-57(Apr 1972).

Aspergillus chevalieri (73070) and its three mutant strains were irradiated with uv rays of 253.7 nm wave-length at 100 ergs/mm$^2$/sec. An exponential survival curve was obtained and the mutation rate showed an increase with increase in dosage followed by a decline with further increase in uv dose. Many mutants obtained differed from the parent strains in colour of the conidia, growth factor requirements and antibiotic production. Amino-acid-requiring mutants were maximum in number, followed by vitamin and purine and pyrimidine requirers. Antibiotic activity among the mutants showed a marked variation leading to an increase or decrease of antibiotic production or complete absence of antibiotic activity. In some cases however antibiotic production had not been affected at all. Strains associated with certain deficiencies did not produce any antibiotic. (auth)

**22688** EFFECT OF CHRONIC GAMMA IRRADIATION ON GENE RECOMBINATION IN PEAS. Monti, L. M. (CNEN, Casaccia, Italy). Z. Pflanzenzuecht.; 68: 64-72(1972).

Reciprocal crosses were performed between two pea lines one of which is characterized by 10 recessive marker genes. The parents and both the plants of the reciprocal $F_1$ crosses were chronically irradiated in a gamma field. Data on the effects of the irradiation on the treated plants were collected and a clear dose effect appears for all the parameters considered for estimating radiosensitivity; no difference was found between the reciprocal hybrids. An $F_2$ analysis was carried out on material coming from the control and the irradiated plants and recombination data among some linked marker genes were collected: no influence of the irradiation was detected on chromosome III (genes st and b) and VII (r and tl); on the contrary, recombination values among three marker genes (s, wb, k) localized in chromosome II increased after irradiation: linkage between s and wb changed from 9.5% to 14.4%, that between wb and k increased from 14.4% to 18.6%, and that between s and k from 21% to 24%. The research shows that a higher frequency of crossovers can be obtained by chronic radiation treatment of $F_1$ plants; the results are explained on the basis of an interference of radiations in the repair concerned with the recombination process. (auth)

**22689** EFFECTS OF PRE-IRRADIATION TREATMENT WITH COLCHICINE AND DES ON TOMATO. Bose, S.; Maiti, S. N. (Univ. of Calcutta). Nucleus (Calcutta); 15: No. 1, 22-30(Apr 1972).

Effects of pre-irradiation treatment with colchicine and diethyl sulfate on x-radioinduced mutations in tomatoes were studied. Changes were observed in germination, chromosomes, and morphology of stems, flowers, and fruits. Inheritance of the mutants showed that they were recessive. Pollen sterility increased with increasing doses of radiation. (HLW)

## Radiation Effects on Animals

### Man

*Refer also to abstracts 22474, 22502, 22618, 22626, and 24209.*

**22690** (ANL-7960(Pt.2), pp 89-92) MACHINE ASSISTED HUMAN CHROMOSOME KARYOTYPING AND ABERRATION SCORING. Brues, A. M.; Cummins, H. T.; Hodges, D.; Simmons, D. J. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Current work on the development of machine methods for karyotyping chromosomes and scoring aberrations in cases of radiation damage is described. The favored approach is a system of interaction between a human operator and computer programs, employing the ALICE image processing system. (auth)

**22691** (BNL-50365) POTENTIALITIES OF PROTON RADIOTHERAPY. Report on symposium held August 9-10, 1972. Archambeau, J. O.; Bennett, G. W. (Brookhaven National Lab., Upton, N. Y.). Aug 1972. Contract AT(30-1)-16. 28p. Dep. NTIS $4.00.

The rationale of the development of proton irradiation facilities for cancer therapy in the US is discussed. It is pointed out that proton beams have been used in general radiotherapy in Sweden and in the USSR, but only to a limited degree in the US; except for pituitary ablation at one hospital. The dosimetric and radiobiological characteristics of proton beams are reviewed, and proton dose distribution for therapy is compared with x radiation. It is concluded that proton beams offer physical advantages over x radiation, since the tumor dose could be increased while the dose to normal tissues would be decreased. The economic aspects of clinical trials of proton beam cancer therapy in the US are discussed. (CH)

**22692** (BNWL-SA-4449(Dr)) STATISTICAL STUDY OF RADIATION DOSE FOR FISHERMEN. Beetle, T. M. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Dec 1972. Contract AT(45-1)-1830. 19p. (CONF-730110-1). Dep. NTIS.

From Statistics and the environment symposium; Los Angeles, California, USA (29 Jan 1973).

During the operation of the production reactors at the Hanford installation in Washington, the Columbia River water that was used for cooling carried small quantities of radionuclides into the river. This created pathways for potential external and internal exposure for the local population, and, as a result, the river became the subject for several research projects. One project involved a study of local sport-fishing activities for the purpose of estimating a component of radiation dose associated with such activities. A time/space frame of units was defined for the river area and time period of interest. Fishing activity quantities were defined for the units in a manner that would allow estimation of annual area totals from data for a sample of units. A multistage sampling plan and related estimation procedures were designed for the purpose of estimating the number of fishermen, the number of fish caught, the time spent fishing, and other quantities of interest. The study provides an illustration of an application of statistical concepts for investigating a relationship between an environmental disturbance and a human population. (HLW)

**22693** (CONF-710847) PROCEEDINGS OF THE 3RD NORDIC RADIATION PROTECTION CONFERENCE, COPENHAGEN, AUGUST 18-20, 1971. (Nordic Society for Radiation Protection, Helsinki (Finland)). 1971. 394p. (In several languages).

Thirty-eight papers are presented arranged according to the following topics: radiation protection of patients, nuclear power plant problems, and other subjects. Separate abstracts were prepared for each of the papers. (Denmark)

*For abstracts of individual papers see: 22176, 22477-22479, 22482, 22493, 22494, 22502, 22618, 22626, 22694-22711, 22768-22772, 22792-22794, 23017, and 24209.*

**22694** (CONF-710847-, pp 11-18) PROBLEMS IN PATIENT PROTECTION IN X-RAY DIAGNOSIS. Flatby, Jon (Statens Inst. for Stralehygiene, Oslo). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

The general situation and the development in the field of patient protection in x-ray diagnosis during the last decade is reviewed. An increase in the examination rate of about 50% over this period has been reported from some countries. The simultaneous reduction in individual gonad doses is considered hardly major. Protection of the gonads is not yet carried out in routine practice. An important issue is the design of handy protective devices, which easily can be applied to the patient. Some of the physical and technical factors in patient protection are discussed. The importance of limiting the useful beam to the smallest practicable size is stressed, and examples are mentioned. The ICRP Publication 16: "Protection of the Patient in X-ray Diagnosis" is discussed together with some of its fundamental ideas and recommendations. (auth)

**22695** (CONF-710847-, pp 19-23) X-RAY DOSES TO THE EYE IN CAROTID ANGIOGRAPHY. Jacobsen, H. H. (Rigshospitalet, Copenhagen). 1971. (In Danish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

With an automatic film-changer in cerebral angiographies there is danger of approaching the cataractogeneous eye doses. Measurements in 19 patients showed an average dose on the focus-near eyelid of 320 mR per exposure. Therefore when repeating the cerebral angiographies, eventually supplemented with air studies, the permissible margin will be very narrow. (auth)

**22696** (CONF-710847-, pp 25-34) GONAD-DOSES IN X-RAY EXAMINATIONS OF CHILDREN. Jacobsen, Lars (Rigshospitalet, Copenhagen). 1971. (In Danish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

The problems of radiation hygiene in abdominal x-ray examinations are discussed. Material on children with abdominal examinations performed together with double gonad-dose measurements, is presented. The measurements were carried out during unchanged routine procedures. The gonad doses applied at various abdominal types of x-ray examinations in this material turned out to be of the same order of magnitude as the minimum figures in larger materials investigated with regard to the same types of radiodiagnostic examinations. On this basis the importance of separate gonadal shielding (lead-rubber protection) and of equipment designed to afford a maximum of shielding is pointed out. Application in practical radiation hygiene is discussed and some suggestions made: (1) close team-work between radiologist and clinician, (2) radiological evaluation and advice with regard to roentgenological possibilities and potential damages in the single cases, and (3) periodical gonadal dose measurements, to evaluate the dose level routine work and to encourage radiographers to protect patients and themselves sufficiently. (auth)

**22697** (CONF-710847-, pp 35-38) GENETICALLY SIGNIFICANT DOSE FROM X-RAY EXAMINATIONS IN FINLAND IN 1970. Ojala, O. A. K. (Inst. of Radiation Physics, Helsinki). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

The genetically significant dose (GSD) is determined by considering five x-ray examinations, which cause almost 60% of the total GSD, according to the Finnish study of 1963. That study is also utilized in the statistical consideration of the total dose. Gonadal and foetal doses were recorded with TL dosemeters that were placed inside the Rando phantom in the five examinations. The GDS was found to be 19.4 mrems, varying within the limits of 16 and 24 mrems. (auth)

**22698** (CONF-710847-, pp 39-42) RADIATION PROTECTION IN PATIENTS IN MODERN DIAGNOSTIC RADIOLOGY. Principal Views. Villaume, Cecil (Radiologisk afdeling, Sygehuset, Denmark). 1971. (In Danish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

The rapid acceleration of progress within the field of diagnostic radiology has involved considerable problems concerning an adequate control of the x-ray doses of our patients. An attempt to control and determine doses in a busy department using the R × cm$^2$ method, and calculation of the absorbed doses, is described. This procedure is considered to have many advantages in a busy x-ray department, as the method does not interfere with the work. Patient dosage is kept as low as possible by this means and protective measures can be continuously improved. Combination of the R × cm$^2$ method with thermoluminescent dosimetry is planned. (auth)

**22699** (CONF-710847-, pp 43-46) DENTAL X-RAY DOSES TO THE PATIENT. Heikkilae, M. (Inst. of Radiation Physics, Helsinki). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

Radiation doses were investigated in different parts of the patient's head with an American Machlett-Alderson Rando Phantom. All the measurements were made by irradiating $Li_2B_4O_7$:Mn thermoluminescence dosemeters in the phantom. The left premolars were exposed with regular dental radiography equipment. The doses with an intraoral device were measured by exposing both the lower and the upper jaws. The third investigated type of dental device was an orthopantomograph. The doses to the patient are from one single exposure. (auth)

**22700** (CONF-710847-, pp 47-50) DOSE-REDUCING FLUOROSCOPY SYSTEM. Petersen, K. O.; Dorph, S.; Okholm, B. (Gentofte Hospital, Copenhagen). 1971. (In Danish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

A system based on pulsed fluoroscopy and image storage on a video disc recorder was developed to reduce fluoroscopic x-ray doses. It can be applied to any radiologic examination requiring fluoroscopy. A disc recorder was used in connection with a conventional x-ray unit. Separate dose measurements for fluoroscopy and film-exposure radiation were obtained from 50 examinations of the stomach. The results were compared to those in 50 conventional fluoroscopy studies. Average 90% reduction in fluoroscopy dosage was obtained, using one 40 msec per sec. Stepwise changing of the fluoroscopic images permitted sufficient impression of gastric dynamics. (auth)

**22701** (CONF-710847-, pp 51-57) INVESTIGATION OF THE EFFECT OF A CONVENIENT DEVICE FOR THE PROTECTION OF THE TESTICLES IN X-RAY EXAMINATIONS. Lindholmer, E. (Bispebjerg Hospital, Copenhagen); Berg, O. 1971. (In Danish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

The Picker lead-rubber gonad protector was modified by mounting two springs in the two channels along its opening slit. This protector was compared with the Mavig solid gonad protector regarding both practical applicability and protection effect. The LiF-thermoluminescence technique was used, and cumulated gonad doses were measured during 4 × 10 urographies (1) with the new protector, (2) with the Mavig protector, (3) with conventional lead-rubber plate protection, and(4) without protection. Individual gonad doses were measured during five urographies using the new protector and during seven urographies using the Mavig protector, and it was demonstrated that the effect of the modified Picker protector is just as good as that of the Mavig protector. It is easy to apply with little manipulation and with no discomfort to the patient. (auth)

**22702** (CONF-710847-, pp 59-62) EQUIPMENT FOR THE CONTROL OF RADIATION DOSES TO THE PATIENTS DURING TREATMENT AT TELE-COBALT UNITS, RADIUMHEMMET, STOCKHOLM. Baaryd, I.; Olofsson, A. (Statens Straalskyddinstitut, Stockholm). 1971. (In Swedish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

The control system worked out for one of the cobalt therapy units at Radiumhemmet is intended for measurement of the entrance dose. The treatment time and the selected wedge filter are also recorded. The entrance dose is measured by a solid-state diode placed in the center of the treatment field. The treatment time set and the entrance dose measured are digitally recorded and can be plotted on the patients' treatment cards. The wedge filter used is identified by a code number, which also is plotted on the treatment card. (auth)

**22703** (CONF-710847-, pp 85-94) DIAGNOSTIC ULTRASOUND USED AS AN ALTERNATIVE FOR X-RAY EXAMINATION IN PREGNANCY. Experimental Work About Possible Teratogenic Effects of Diagnostic Ultrasound. Bang, Jens (Univ. of Copenhagen). 1971. (In Danish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

During the last 10 to 12 yrs, application of ultrasonics for diagnostic purposes in medicine has increased especially in obstetrics. It was found reasonable in order to obtain qualitative and quantitative evaluation to investigate the teratogenic effects, if any, of ultrasound with frequences equalling those applied for diagnostic purposes in comprehensive animal experiments. An investigation including a little more than 6500 fetuses of mice exposed to ultrasound of high effect was carried out. Both continuous and pulsed 2.25 MHz ultrasound were used in the experiment. (auth)

**22704** (CONF-710847-, pp 95-114) RADIATION SAFETY IN THE NUCLEAR POWER FIELD. Speculations on Future Needs. Bergstroem, S. O. W. (Aktiebolaget Atomenergi, Studsvik, Sweden). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

Personal viewpoints on the present situation and future development of radiation control in the nuclear power field are presented. The special areas discussed are personnel education, dosimetry and instrumentation, waste handling, radiation protection norms, and fundamental research. The presentation is focused on conditions in the Nordic countries up to A. D. 2000. The average educational need is estimated to be of the order of 10 radiation protection officers and 100 reactor operators and similar personnel per year during the three decades considered. A cheap and reliable dose alarm for external doses up to 2 rems is suggested as an addition to the otherwise fairly satisfactory instrument market. More radiation protection built into layouts and component designs is advocated. (auth)

**22705** (CONF-710847-, pp 115-123) ATOMIC POWER REACTORS. Biological and Occupational Hygiene Aspects. Oftedal, P. (Univ. of Oslo). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

Against the background of the reduced maximum permissible doses now instituted by various responsible health authorities, the following points are discussed: (1). The complexities of weighing economic and biological aspects of radiation hygiene in the dose region in question. (2). The quantification of benefits and disadvantages has been carried further in the atomic power field than in most other activities in society, and the investment per life saved appears to be higher in the atomic power industry than in most other activities. The need for similar quantifications in other fields (e.g. food additives) is discussed, and the advantages of seeking to adapt the radiation MPD to other noxae in terms of rad-equivalents is stressed. (auth)

**22706** (CONF-710847-, pp 177-202) DETERMINATION OF RADIATION DOSES IN THE VICINITY OF A NUCLEAR POWER PLANT AT A REACTOR ACCIDENT. Wahlstroem, Lars (Swedish State Power Board, Stockholm). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

At a reactor accident when radioactive material is released to the vicinity, it is of importance that the authorities are as soon as possible informed of the doses to the population. Such a calculation based on one "standard release" can be made in advance and presented in diagrams. At an accident, the doses are to be corrected to the actual presumptions. (auth)

**22707** (CONF-710847-, pp 311-320) PRACTICAL VALUE OF CHROMOSOME ANALYSIS IN RADIATION PATHOLOGY. Visfeldt, Jakob (Frederiksberg Hospital, Copenhagen). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

In biological dosimetry chromosome analyses are indicated in cases of: acute whole-body irradiation; acute non-uniform or partial-body irradiation; suspected exposure to irradiation to an unknown extent; and chronic external irradiation. For studies of chronic internal irradiation and of in vitro systems chromosome analyses are also of value. (auth)

**22708** (CONF-710847-, pp 321-338) APPLICATION OF WORK STUDIES IN HEALTH PHYSICS WORK. Vagslid, Torgeir (Institutt for Atomenergi, Kjeller, Norway). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

The Health Physics Dept. at the Institutt for Atomenergi, Kjeller, has used work study techniques to find the most rational procedures for reducing doses received by the production personnel at the Isotope Laboratory. The methods by which a combination of work study techniques and dose rate measurements permitted registration and evaluation of the various factors and allowed the setting-up of priorities from improvements are described. They resulted in a considerable reduction in the doses received by the personnel at the Isotope Laboratory. (auth)

**22709** (CONF-710847-, pp 347-357) PERSONNEL PROBLEMS AND RADIATION HYGIENE IN GYNECOLOGICAL RADIOTHERAPY. Netteland, Olav (Norwegian Radium Hospital, Oslo). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

A preliminary report is given on personnel exposure in relation to working conditions for the ward personnel of The Gynecological Department, The Norwegian Radium Hospital, Oslo. The investigations covered the period 1958 to 1970, during which the personnel directly engaged in gynecological radium therapy were the only group exposed to biologically relevant doses. During that period the technical conditions as well as the treatment methods and the practical working conditions for the personnel were well standardized. In spite of this, variations in personnel exposure seemed to be quite irregular in relation to the number of treated patients and the amount of used radioactive material per year. The corrected dose curve indicates a marked influence by nonphysical factors, most likely working conditions, and social factors. The exposure situation for the closely cooperating groups nurses and nurses aids is compared and studied in detail. The effect on health physical conditions by personnel turnover in both personnel groups is studied numerically and the results indicate remarkable coincidences and high correlation between personnel exposure curves and Stress curves. Results are discussed. (auth)

**22710** (CONF-710847-, pp 359-366) CONSIDERATIONS ON PREMISES AND PRACTICAL RISKS IN TECHNICAL RADIATION PROTECTION. Netteland, Olav (Norwegian Radium Hospital, Oslo). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

During several years of extensive practical experience it was proved that in modern hospitals most of the controlled personnel groups are exposed to very low yearly doses of only negligible biological importance, which indicates extreme overprotection compared to the original shielding premises. The economic and technical consequences should be critically evaluated, but more important, such overprotection may have a negative influence on radiation understanding and behavior of the involved personnel. Obvious overprotection of most personnel groups in a hospital may give psychological and social problems in the few groups still exposed to relatively high doses and for which the existing radiation hazards can be eliminated only by radical technical improvements and corresponding economic efforts. The need of revision of the existing practical norms and regulations should be investigated. (auth)

**22711** (CONF-710847-, pp 367-369) RADIATION EXPOSURE ACCIDENT WITH X-RAY DIFFRACTION UNIT. Bull, Arne (Univ. of Oslo). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

At the University of Oslo, a great number of x-ray diffraction units are used, many of them fitted with self-made accessories. One of them, operating a Weissenberg camera, developed a fault in the beam shutter system, and a warning system was overlooked owing to special circumstances. The operator was exposed to the direct beam for about three minutes while making adjustments by looking in a microscope. The unprotected left eye and the nearby skin of the face was exposed to approximately 720 R, resulting in approximately 175 rads to the lens of the eye. Personal film dosimeter showed no exposure. Repeated medical examinations have been negative. (auth)

**22712** (ORNL-TM-4078) CALCULATION OF THE DOSE INDUCED IN TISSUE BY NEGATIVELY CHARGED PION BEAMS. Armstrong, T. W.; Alsmiller, R. G. Jr.; Chandler, K. C. (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 61p. Dep. NTIS.

Calculations were carried out using the Monte Carlo radiation transport code HETC to determine the spatial distribution of the absorbed dose produced in tissue by monoenergetic negatively charged pion beams. The depth dependence of the absorbed dose has been computed for narrow (zero width) negative-pion beams incident normally on one side of a slab of tissue 60 cm thick. Beam energies of 53, 82, and 108 MeV (corresponding to ranges in tissue of approximately 10, 20, and 30 cm) were used. For the beam having a range of 20 cm, the absorbed dose as a function of the lateral distance from the beam axis has also been computed. The use of the results from monoenergetic beams to synthesize the incident-energy distribution needed to produce desired depth-dose distributions for therapy is discussed, and, as an example, the energy spectrum of the incident beam required to produce a uniform absorbed dose over the depth interval from 20 to 30 cm is computed. (auth)

**22713** (ORNL-TM-4159) PROGRESS REPORT, SEPTEMBER 1, 1972–FEBRUARY 28, 1973 ON THE RESEARCH PROJECTS: CALCULATIONS FOR CANCER RADIOTHERAPY WITH NEGATIVE CHARGED PIONS AND A COMPARATIVE STUDY OF THE USE OF PHOTONS, NEUTRONS, PROTONS, NEGATIVELY CHARGED PIONS, AND HEAVY IONS IN CANCER RADIOTHERAPY. (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 73p. Dep. NTIS $5.75.

The biological and physical parameters relevant to dose distribution for a number of charged particles of interest for use in radiotherapy were compared with those of conventional $^{60}$Co $\gamma$. Computer calculations were made of the stopping power and range of negatively charged pions, neutrons, and protons. The calculational techniques and cross-section data used are described. (CH)

**22714** (RPS-AR-5) ANNUAL REPORT FOR THE YEAR 1971. (Ministry of Public Health, Bangkok (Thailand). Radiation Protection Service). [nd]. 38p. Dep. NTIS (U. S. Sales Only) $4.00.

In Thailand responsibility for all aspects of the use of ionizing radiations is invested in the Atomic Energy Commission for Peace. Activities during 1971 included: the calibration of $\gamma$ and x ray sources used for therapy and a number of diagnostic x ray machines; radiation protection surveys in diagnostic x ray institutions; personnel dosimetry; and preliminary work on a study of the population dose due to diagnostic x ray examinations. (CH)

**22715** (SZS–131) BIOCHEMICAL CHANGES IN BLOOD AND URINE INDICATING RADIATION DAMAGE. A Literature Review. Part II. Orban, U.; Solle, M. (Staatliche Zentrale Fuer Strahlenschutz, Berlin (East Germany)). Jun 1972. 21p. (In German). Dep. NTIS (U. S. Sales Only).

A literature survey was made on changes of enzyme activity in blood and urine of animals and humans caused by external and internal irradiation. These data are evaluated from the viewpoint of application to biological dosimetry. Emphasis was placed on changes in the activity of lactate dehydrogenase, glutamate oxaloacetate transaminase, glutamate pyruvate transaminase, and alkaline phosphatase. (113 references) (auth)

**22716** (TID–26295) JOINT DENTAL RADIATION SURVEY, PUERTO RICO 1968. Gileadi, M. (Puerto Rico Nuclear Center, Rio Piedras). Jan 1973. 168p. Dep. NTIS $10.50.

A survey was made on the utilization of diagnostic dental x ray examinations in Puerto Rico during 1968. The data were used to estimate the radiation dose to the gonads and skin as a factor of age and sex and the contribution of diagnostic dental radiography to the annual radiation dose of the population. (CH)

**22717** DILEMMA OF DELAYED RADIATION INJURY OF THE LARYNX. Calcaterra, T. C.; Stern, F.; Ward, P. H. (Univ. of California, Los Angeles). Ann. Otol., Rhinol., Laryngol.; 81: No. 4, 501-507(Aug 1972).

Delayed or recurrent laryngeal edema following curative-dose irradiation for laryngeal cancer presents a diagnostic problem for the laryngologist. Although the edema may merely represent a prolonged response to irradiation, the possibility of residual carcinoma must be considered. Some reluctance to laryngeal biopsy was exercised to avoid inciting a fulminant perichondritis. A series of 11 patients with delayed irradiation edema is presented, eight of whom had residual carcinoma. Earlier and frequent laryngeal biopsies are recommended for these patients because of the high incidence of residual carcinoma with its poor prognosis. (auth)

**22718** RADIOLOGIC HEALTH CONSIDERATIONS IN PEDIATRIC NUCLEAR MEDICINE. Hiscock, R. R. (Sinai Hospital of Baltimore, Inc.). Radiol. Technol.; 44: No. 5, 312-316(1973).

Recent innovations and refinements in nuclear medicine have broadened the scope of this specialty to include more pediatric studies. Because of the potentially hazardous effects of radiation exposure on children, care must be exercised in procedure methodology. The performance of a safe and worthy examination is an index to the technologist's theoretical and applied knowledge. Thoughts of various technical parameters and their effects on test quality and resultant radiation exposure to the patient are presented with the hope of influencing technologists in their approach to the performance of pediatric nuclear medicine examinations. (auth)

**22719** TECHNOLOGY ASSESSMENT OF RISK REDUCTION EFFECTIVENESS OF WASTE TREATMENT SYSTEMS FOR LIGHT-WATER REACTORS. Martin, J. E.; Galpin, F. L.;

Fowler, T. W. (Environmental Protection Agency, Rockville, MD). Radiat. Data Rep.; 14: No. 1, 1-8(Jan 1973).

The Environmental Protection Agency (EPA) routinely performs technology assessment of applications of nuclear energy that have the potential to introduce radioactive material into the environment. The Agency has extensively examined the performance of waste treatment systems for light water power reactors as a function of cost with regard to an examination of bases for environmental radiation standards and for EPA review of environmental impact statements for such plants. It was determined that significant and cost effective offsite dose reductions from gaseous discharges could be brought about by using available technology to hold up the gases until essentially krypton-85 remained; further dose reductions by cryogenic removal of krypton-85 did not appear to be justified in view of the costs involved. Similarly for liquid wastes, reasonable technology appears to stop just short of recycling waste streams to contain tritium. (auth)

**22720** TEORIYA I PRAKTIKA AVIATSIONNOY MEDITSINY. (Theory and Practice of Aviation Medicine). Isakov, P. K. Moscow; Meditsina (1971). 396p.

The following topics are discussed in the book: flight conditions and typical features of the occupation of flying; brief history of the development of Soviet aviation medicine; influence of factors of high-altitude flight on the human organism; influence of accelerations on the organism; the influence of vibrations and motion sickness on the organism; hygiene in aviation; aviation toxicology; aviation pharmacology; radiobiology in aviation; some questions of aviation ophthalmology; aviation otolaryngology; typical features of the psychophysiological and hygienic requirements for the pilot's working location; oxygen breathing apparatus and medical check on the high-altitude training of flight personnel; equipment for emergency abandonment of aircraft and medical checks on flight personnel training for forced abandonment; evacuating wounded and sick persons by air; medical monitoring of flight safety; psychological selection of candidates for flight schools; typical features of medical monitoring of the health of engineering-technical personnel who service flights; medical analysis and preventing the causes of flight accidents and preconditions for them; specific features of certain types of flights and their medical support; and current problems of aviation medicine. (ERB)

**22721** FERTILITY AMONG FEMALE SURVIVORS OF THE ATOMIC BOMBS OF HIROSHIMA AND NAGASAKI. Blot, W. J. Sawada, H. (Atomic Bomb Casualty Commission, Hiroshima). Amer. J. Hum. Genet.; 24: 613-622(Nov 1972).

Information concerning the reproductive histories of 2,345 Hiroshima and Nagasaki women subject to varying degrees of radiation exposure from the atomic bombs of 1945 was obtained from personal interviews. From this information, the likelihood of conception over a span of years from immediately following exposure through nearly 2 decades later was calculated. Significant differences in percentages of marriages without conception according to practice of contraception and city of residence were found. Significant differences in rates of pregnancy by city, marriage length, and parity were also shown. However no evidence that exposure to high doses (100+ rad) of atomic radiation has impaired subsequent fertility was uncovered. (auth))

**22722** RADIOTHERAPY AND CARCINOMA OF THE PAROTID. Patey, D. H. Brit. Med. J.; 1: No. 5847, 236(27 Jan 1973).

Brief mention is made of the high percentage of carcinomas of the parotid arising in pleomorphic adenomas, primary or recurrent. Two cases are briefly described. The first (aged 27) has a carcinoma arising 6 years after radiotherapy for a pleomorphic adenoma following enucleation. The second occurred in a man aged 30, who at the age of 11 had received radiotherapy following recurrence of adenoids after surgery. (auth)

**22723** CHROMOSOME ABERRATIONS IN MEN OCCUPATIONALLY SUBJECTED TO PROLONGED GAMMA EXPOSURE. Bocian, E.; Ziemba-Zak, B. (Inst. of Nuclear Research, Swierk, Poland). Nukleonika; 17: No. 12, 656-661(1972). (In Polish).

The incidence of chromosome aberrations was studied in peripheral blood lymphocytes of 14 employees of the Institute of Nuclear Research who had accumulated 2 to 13 rems of gamma irradiation over a period of 1 to 9 years. The number of dicentric chromosomes, acentric fragments, and the number of chromatid aberrations have been determined. Numbers of dicentric chromosomes, acentric fragments, and the number of total structural aberrations are greater in the studied group than in the control group. The differences between these two groups are statistically significant. (auth)

**22724** CERVICAL PLEXUS LESIONS FOLLOWING POST-OPERATIVE RADIATION THERAPY OF MAMMARY CARCINOMA. Westling, P.; Svensson, H.; Hele, P. (Umeaa Univ., Sweden). Acta Radiol., Therm., Phys., Biol.; 11: No. 3, 209-216(Jun 1972).

Lesions of the cervical plexus following post-operative radiation therapy for mammary carcinoma are described. The symptoms and signs of these range from slight sensory and motor disturbances to severe paralysis. The literature on the subject is reviewed and the dose-time effect relations are discussed. (auth)

**22725** RADIATION CANCERS IN THE HEAD AND NECK REGION. Sato, T.; Maeda, K.; Takayama, S. (Osaka Univ.). Jibi Inko-ka; 44: No. 11, 861-868(Nov 1972). (In Japanese).

Thirty-six cases of radioinduced carcinoma in the regions of the pharynx, larynx, thyroid, and face are reported. In 28 of these cases, the cancer occurred as a consequence to radiation therapy for benign diseases and the eight others following radiation therapy for cancer of the pharynx, larynx, and thyroid that was primarily successful in each case. In five cases, the possibility of the presence of multicentric field of carcinogenesis is noted. Furthermore, in six cases duplicate carcinomas in the irradiated region as results of localized reaction are also recognized. (auth)

**22726** RADIOLOGIC PULMONARY CHANGES FOLLOWING $^{60}$Co TREATMENT OF MAMMARY CARCINOMA. Hagen, S.; Kolbenstvedt, A. (Norwegian Radium Hospital, Oslo). Acta Radiol., Ther., Phys., Biol.; 11: No. 5, 386-394(Oct 1972).

Seventy patients with stage I and stage II mammary carcinoma were treated by radical mastectomy followed by irradiation with cobalt-60. Routine follow-up chest films revealed post-radiation changes in 61 patients (87%). It appears that the changes may end as an irreversible fibrous stage and that they are more marked in the higher age groups. (auth)

**22727** ATROPHY FOLLOWING RADIATION THERAPY FOR CENTRAL NERVOUS SYSTEMS NEOPLASMS. Wilson, G. H.; Byfield, J.; Hanafee, W. N. (Univ. of California, Los Angeles). Acta Radiol., Ther., Phys., Biol.; 11: No. 4, 361-368(Aug 1972).

When symptoms do recur following irradiation, it is important to keep in mind the possibility of radiation damage rather than a recurrence of tumor as a cause for the symptoms, regardless of the dose delivered, particularly when such radiosensitive areas as the brain stem are included in the treatment field. It is essential that the patient be reevaluated by neuroradiologic investigations to determine if, in fact, the symptoms are related to radiation damage. (auth) (Sweden)

**22728** X-RAY EXPOSURE OF CHILDREN DUE TO DIAGNOSTIC EXAMINATIONS OF THE KIDNEYS AND THE URINARY TRACT. Weber, C. Tuebingen, Ger.; Tuebingen Univ. (1971). 64p. (In German).

Thesis.

The volume dose and the gonad dose were calculated on the basis of the dose per surface unit and additional measurements on a phantom. In addition, the gonad dose administered to patients was measured for each patient separately. The calculated gonad dose to female patients was between 40 and 60 mrad per IVP, whereas the measured dose was between 40 and 70 mrad. A comparison with the natural annual gonad dose showed that these doses amount to 60 to 120% of the natural gonad dose. For male patients, it was calculated that the gonad dose is below 10 mrad per IVP if the gonads are protected by a lead shield and are situated below the lower limit of the radiation field. Without lead protection, the dose to the gonads is increased to 25 to 40 mrad. The volume dose was determined to be 100 g rad (for infants) up to 600 g rad (for school children), which means 10 to 20% of the annual natural volume dose. For examinations by Mictions-Cysto-Urethrography, only directly measured values are available. The gonad dose to female patients examined by MCU being 200 to 300 mrad, that to male patients 30 to 40 mrad. (GF)

**22729** IONIZING RADIATION AND VINCRISTINE: POSSIBLE NEUROTOXIC SYNERGISM. Byfield, J. E. (Harbor General Hospital, Los Angeles). Radiol. Clin. Biol.; 41: No. 3, 129-138 (1972).

A case of radiation myelitis occurring in a child who received cobalt irradiation at less than 4 months of age is reported. Dose fractionation was below that in which radiation myelitis was previously reported when orthodox treatment schedules were used. The patient received coincident vincristine treatments that may have sensitized the central nervous system to otherwise reversible radiation damage developing in the post-radiation period. Radiation myelitis and vincristine neurotoxicity are reviewed and the suggestion of a potential neurotoxic synergism is briefly discussed. (auth)

**22730** ETIOLOGY, DIAGNOSIS, AND MANAGEMENT OF PERICARDIAL EFFUSION AFTER IRRADIATION. Kagan, A. R.; Hafermann, M.; Hamilton, M.; Pierce, R.; Morton, D.; Johnson, R. (Cedars-Sinai Medical Center, Los Angeles). Radiol. Clin. Biol.; 41: No. 3, 171-182(1972).

The mediastinums of 109 patients were irradiated. One half had a positive PA chest radiograph for Hodgkin's disease. A dose time analysis of these patients has shown that the condition of the mediastinum is as important as the dose to the anterior surface of the heart in the pathogenesis of radioinduced pericardial effusion. (auth)

**22731** EFFECTS OF FRACTIONATED DOSES OF ELECTRONS ON HUMAN SKIN. Belletti, S.; Tunesi, G. (Spedali Civil, Brescia, Italy). Acta Radiol., Ther., Phys., Biol.; 11: No. 5, 490-500(Oct 1972).

Several types of dose fractionation were evaluated in patients treated after amputation of the breast for carcinoma and irradiated with 15-MeV electron beams to bilateral parasternal lymph nodes. Reactions observed in the same patient with different types of fractionation are plotted and the resulting curves compared with results reported by other workers. (auth)

## *Vertebrates*

**22732** (CEA-CONF-2156) PLASMA TRANSAMINASES AFTER IRRADIATION. Dose-Effect Relationship and Prognostic Value. Breuil, L.; Valle, C.; Tellier, P. (Commissariat A L' Energie Atomique, Fontenay-Aux-Roses (France). Centre D' Etudes Nucleaires). 1972. 10p. (In French). (CONF-720981-1). Dep. NTIS (U. S. Sales Only).

From 9th annual meeting of the European Society for Radiation Biology; Rome, Italy (26 Sep 1972).

In order to find an early biological indicator of radiobiological damage, the activities of glutamate oxaloacetate transaminase and glutamate pyuravate transaminase (GOT and GPT transaminases) in the plasma of 9 lots of 8 rats irradiated with $^{60}$Co $\gamma$ rays were determined at doses of 100, 200, 300, 400, 500, 600, 750 (LD 50), 850 (LD 100), and 1200 rads (gastro-intestinal syndrome). Six hours after irradiation, the animals underwent cardiopuncture, following nembutal anaesthesia. It was observed that the GOT increased with the dose received. Neutron irradiation (upper limit of the spectrum: 2 MeV) at doses of 100, 250, 400, and 700 rads showed a GOT increase according to the dose, of the same amplitude as with the $\gamma$ rays, an identical increase occurring for much lower doses, with an RBE of 3 to 3.5. The $\gamma$ irradiation results show that there is a dose-effect relationship between the GOT level at the 6th hour and the dose received. They appear to allow a prognostic value to be given to the degree of GOT increase. (CH)

**22733** VARIATION IN REACTIVITY OF AN IRRADIATED ORGANISM. Gorizontov, P. D.; Klemparskaya, N. N. pp 19-29 of Problemy Immunologicheskoi Reaktivnosti i Allergii. Moscow; Meditsina (1971). (In Russian)

The change in allergic reactivity and the induction of autoallergic processes as a result of ionizing radiation were studied. A survey of the work in this field including research procedures and results is presented. Two different procedural paths are considered: the discovery and description of certain changes in the structure and function of individual organs and systems and evaluation of the integral index of reactivity of the organism as a whole, that is, the adequacy of coordinated functioning of all its systems. Graphs are presented showing the effect of homosensitization on the survival rate of irradiated mice; the increase in the death rate of irradiated mice under the effect of subcutaneous injection of 0.5 ml of 25% spleen extract 5 hours after irradiation; leukocyte damage in a rabbit irradiated with 600 roentgens 30 days after irradiation on contact with homologous tissue antigen; the dynamics of appearance of autoantibodies in irradiated (600 roentgens) and sensitized rabbits (fivefold intra-abdominal injection of 10 ml of a mixture of equal parts of 10% homogenate of homologous tissue of the liver, kidneys and intestine); and the titration dynamics of autoantibodies in rabbits after irradiation with 800 roentgens for DNA and renal antigen; and for the renal antigen of dogs after repeated irradiation with a lethal dose of 360 roentgens. Experimental results are analyzed and the mechanisms discussed. (JPRS)

**22734** IN-VITRO INCORPORATION OF $^{14}$C-1-ACETATE AND $^{32}$P ORTHOPHOSPHATE IN TRIGLYCERIDES OR PHOSPHATIDES OF MATERNAL AND FETAL LIVER IN NORMAL, SHAM-IRRADIATED, AND X IRRADIATED (800 R) PREGNANT RATS. Haude, W. (Friedrich-Schiller-Univ., Jena, Ger.). Acta Biol. Med. Ger.; 28: No. 6, 989-997(1972). (In German).

In connection with the demonstration of increase in triglycerides in maternal and fetal liver following total irradiation, the in vitro incorporation of $^{14}$C-1-acetate and $^{32}$P orthophosphate into liver lipids of mother and fetus was studied 24 hr following total irradiation (800 r) of pregnant rats from the 19th day of gravidity, in order to elucidate the pathogenesis of this process. In the maternal liver, the incorporation of acetate into triglyceride fatty acids of both irradiated and sham-irradiated starving animals, as compared with untreated controls, was strongly reduced. The incorporation was stimulated by the irradiation, but still remained far behind that of normal animals. In fetal liver, no significant differences have been detected. The incorporation of phosphate in maternal liver of sham-irradiated and irradiated starving animals was increased by about 40 percent over that of normal animals, whereas no significant differences were demonstrable in fetal liver. It is concluded from the results that neither an increase in fatty acid synthesis, nor a reduction of phosphatide synthesis comes into question as the pathogenic factors for the irradiation-induced increase in triglycerides. (auth)

**22735** ASSAY OF THE RADIOPROTECTIVE AND THERAPEUTIC PROPERTIES OF S-2-BENZIMIDAZOLYL MERCAPTOPROPIONE-N-/p/TOLYL/HYDRAZIDIMIDE IN SINGLE AND FRACTIONATED IRRADIATION. Pantev, T.; Bokova, N.; Nikolov, I. Rentgenol. Radiol.; 10: No. 4, 258-263(1971). (In Bulgarian).

The radiobiological properties of a member of the mercaptoalkylhydrazidine group were studied. The radioprotective and therapeutic effects of the preparation were studied in rats exposed to fractionated irradiation with a total dose of 1500 R divided in daily doses of 100 R. The preparation was administered before and after each irradiation procedure. The therapeutic effect of the radioprotector was also studied on its repeated administration before and no longer than one hour after exposure to the minimal absolute lethal dose. The preparation was shown to exert a significant therapeutic effect. The survival rate and the mean duration of life served as criteria for the assessment of the integral radiobiological effect; the splenic and small intestinal dry weight changes and the femoral bone marrow cell counts were used for evaluating the effect on the individual syndromes of radiation sickness. (auth)

**22736** EFFECTS OF WHOLE-BODY IRRADIATION AND HORMONES ON DRUG METABOLISM IN THE LIVER ENDOPLASMIC RETICULUM. Knott, J. C. A.; Wills, E. D. (St. Bartholomew's Hospital, London). Radiat. Res.; 53: No. 1, 65-76(Jan 1973).

The rate of oxidative demethylation of aminopyrine by preparations of microsomes from male rat livers decreased following whole-body irradiation, reaching a minimum, of 25% of the control value, on the 4th and 5th days after 850 rads. Oxidative demethylation in preparations of microsomes from female rats or male or female mice was unaffected by this dose of irradiation. The decreased rate in male rats was caused mainly by an increase of the $k_m$ for the reaction from 0.52 to 1.60 mM. The rate of hydroxylation of biphenyl in the male rat liver was also depressed by whole-body irradiation to a similar extent as oxidative demethylation. Cytochrome $P_{450}$ concentration in the microsomes was unaffected by irradiation, but NADPH cytochrome c reductase activity was depressed. Synthesis and the output of corticosteroids from the adrenal was unaffected by 850 rads whole-body irradiation. Nearly maximum activity of the oxidative demethylation system, as measured by $K_m$, was restored by the injection of testosterone into male rats, and it is therefore considered that a reduced output of this hormone, possibly resulting from reduced anterior pituitary activity, is a primary cause of inhibition of oxidative demethylation and hydroxylation, which follows whole-body irradiation. (auth)

**22737** ALTERATIONS IN $^{86}$Rb EXTRACTION IN NORMAL MOUSE TISSUES AFTER IRRADIATION. An Estimate of Long-Term Blood Flow Changes in Kidney, Lung, Liver, Skin, and Muscle. Glatstein, E. (Mount Vernon Hospital, Northwood, Eng.). Radiat. Res.; 53: No. 1, 88-101(Jan 1973).

Using the method of $^{86}$Rb extraction as developed by Sapirstein, the uptake of this isotope was studied to measure changes in perfusion of normal mouse kidney, lung, liver, skin, and skeletal muscle after regional single doses of 240 kV x-rays estimated to be at or near the level of normal tissue tolerance for viscera. In the kidney, the extraction of isotope declines soon after irradiation and becomes significantly decreased from age controls by 2 months after 1100, 1500, or 1900 rads. This decrease in $^{86}$Rb extraction appears dose-dependent, continues to decline for at least 1 yr, and preceded histologic fibrosis by several months. The uptake of $^{86}$Rb in irradiated lung decreased significantly between 3 and 4 months after which it gradually returned to normal levels. No significant change in $^{86}$Rb extraction was seen in liver, skin, or muscle after doses up to 1500 rads. Details of this isotopic technique and possible implications of perfusion changes in normal tissues for clinical radiation therapy are discussed. (auth)

**22738** RADIOPROTECTIVE EFFECT OF RAUSCHER LEUKEMIA VIRUS IN THE SJL/J MOUSE. II. Development of Radioresistance and the Distribution of Mortality. Markoe, A. M.; Okunewick, J. P. (Allegheny General Hospital, Pittsburgh). Radiat. Res.; 53: No. 1, 11-123(Jan 1973).

Studies were performed to evaluate the development of radioresistance in mice after Rauscher leukemia virus (RLV) infection. In terms of the ability of infected mice to survive the initial 30-day period after exposure to 875 R (a $LD_{95/30}$ exposure for normal mice), increased survival became manifested between 6 and 10 days after RLV inoculation. When RLV-injected mice were x-irradiated at 10, 14, 18, 22, 26, and 30 days after infection, the respective 30-day survival values were 47, 47, 20, 52, 33, and 16%. Median survival times were more than doubled in mice irradiated 10 days after RLV infection, and remained elevated. Likewise, an apparent therapeutic effect of radiation on Rauscher disease lethality became manifested on the tenth day of infection and persisted thereafter. However, since posttreatment mortality is the result of two components, radioinduced mortality and mortality due to Rauscher disease, the 30-day postirradiation survival parameter does not adequately describe the development of radioresistance. Mortality distributions for the infected mice were compared in order to qualitatively derive the contribution of irradiation lethality to the total mortality. Analysis of these distributions indicated that radioresistance developed between 6 and 10 days after infection and increased until no apparent radiation mortality component could be detected by 22 days after RLV infection. (auth)

**22739** IRRADIATION AND VIRAL LYMPHOMAGENESIS IN THYMIC GRAFTS. Hays, E. F. (Univ. of California, Los Angeles). J. Nat. Cancer Inst.; 50: No. 2, 523-528(Feb 1973).

AKR (AK) neonatal thymus was subjected to 850 and 5000 rad $^{60}$Co irradiation in vivo before its removal for grafting to thymectomized syngeneic hosts. These irradiated grafts developed lymphoma after being placed in hosts inoculated as sucklings with cell-free filtrates of Gross Passage A, virus-accelerated AK lymphoma. The incidence was slightly lower and the latent period longer than found in nonirradiated control grafts in similar hosts. However, when thymus was exposed to these filtrates in vitro just before grafting or in vivo 24 hours before grafting, but placed in hosts not given neonatal virus inoculation, lymphoma incidence was reduced in the irradiated grafts when compared to that of virus-exposed nonirradiated control grafts. Thus heavily irradiated thymic grafts could develop lymphoma in virus-infected hosts, but irradiation of grafts exposed to filtrate in vitro and in vivo inhibited the ability of the virus-containing filtrates to produce lymphoma, probably by reducing the numbers of cells available for virus replication. (auth)

**22740** EFFECT OF X IRRADIATION ON INDUCTION OF DELAYED HYPERSENSITIVITY AS MEASURED BY IN VITRO MACROPHAGE MIGRATION INHIBITION. Kaplan, J. (Army Medical Research Inst. of Infectious Diseases, Frederick, MD). RES, J. Reticuloendothel. Soc.; 12: No. 1, 90-95(Jul 1972).

Guinea pigs were given 300 R x-irradiation 24 hours prior to sensitization with bovine gamma globulin. Antibody formation and delayed hypersensitivity as measured by in vitro macrophage migration inhibition were determined 6, 8 and 13 days after sensitization. Suppressed antibody formation was evident in irradiated animals on each day. Eight days after sensitization delayed hypersensitivity first became apparent in unirradiated animals but was absent in irradiated animals. At 13 days after sensitization both groups demonstrated delayed hypersensitivity. These results suggest that cells responsible for the expression of delayed hypersensitivity recover more rapidly from irradiation damage than cells responsible for humoral antibody formation. (auth)

**22741** INCREASED SPLENIC TRANSPLANTABLE COLONY-FORMING UNITS RELATED TO INCREASED RADIORESISTANCE AFTER RAUSCHER LEUKEMIA VIRUS INFECTION OF THE SJL/J MOUSE. Markoe, A. M.; Okunewick, J. P.; Erhard, P.; Phillips, E. (Allegheny General Hospital, Pittsburgh). J. Nat. Cancer Inst.; 50: No. 2, 449-455(Feb 1973).

Using the exogenous colony-forming unit (CFU) assay of Till and McCulloch, changes in splenic CFU content were studied as a function of time after Rauscher leukemia virus (RLV) infection of the SJL/J mouse, and splenic CFU content was related to previously reported changes in radiosensitivity after infection. Total splenic CFU content [colony-forming potential (CFP)/spleen] first increased after the 6th day of infection, correlating with the appearance of splenomegaly and of radioresistance. CFP/spleen continued to increase until day 22 after infection, reaching 16 times normal levels. This increase was positively correlated with greater radioresistance. Beyond the 22nd day of infection, CFP/spleen fell somewhat but was never < 9 times normal values. However, calculations based on existing information regarding spleen cell radiation survival and turnover indicated that this level of splenic CFU was sufficient to provide radioprotection at the level of x-ray exposure used. It was concluded from these studies, that RLV infection increased the number of splenic hematopoietic stem cells of the SJL/J mouse and this increase resulted in the greater radioresistance. (auth)

**22742** PROTON IRRADIATION OF BEAGLE EYES. I. Si(Li) and Thermoluminescent Dosimetry of 20, 35, and 45 MeV Protons. Momeni, M. H.; Cahill, T. A.; Horn, P. L. (Univ. of California, Davis). Radiat. Res.; 53: No. 1, 15-23(Jan 1973).

A Si(Li) solid state detector, CsI, LiF thermoluminescence dosimeters (TLD), and fast film were used to measure proton fluence, energy distribution, and depth dose in a cubical Lucite phantom exposed to beams of 20, 35, and 45 MeV protons. The recoiled deuterons and scattered protons from a deuteron gas chamber were used as a beam monitor during irradiation of the animals. The depth–dose measurements illustrate that thermoluminescence dosimeters can be used to estimate proton exposures in a Lucite phantom for 20 to 45 MeV protons. It also appears that TLD is relatively energy independent over this energy interval. Young beagle dogs' eyes (100 days old) were exposed to 70, 125, 240, and 480 surface rads. The average dose to iris, lens, and retina was calculated from the surface dose and the depth–dose curves. The maximum dose to the lens and retina was about 4.5 times the surface dose, respectively, for 35 MeV and 45 MeV protons. The maximum dose to the iris for the 20 MeV protons was about 2.6 times the surface dose. (auth)

**22743** ROLE OF THE CENTRAL NERVOUS SYSTEM IN REGULATING CELL DIVISION AND RADIOSENSITIVITY OF CHROMOSOMES IN RAT CORNEAL EPITHELIAL CELLS. Tsapygina, R. I. Issled. Genet.; No. 4, 54-61(1971). (In Russian).

The conditioned reflex method (with an electric current serving as an unconditioned stimulus, blue-green light as a conditioned stimulus, and blue-yellow-green light as a differentiating stimulus) was used to study the effect of the nervous system on cell division and induction of chromosomal aberrations in the corneal epithelial cells of CC57BR and CC57W rats. After formation of a positive conditioned reflex, the animals responded to both the unconditioned and conditioned stimulus with a significant decrease in the mitotic index in the corneal epithelium, whereas the differentiating stimulus did not have this effect. X-irradiation of the animals 2½ hours before presentation of the conditioned and unconditioned stimuli resulted in a lowering of the level of induced chromosomal aberrations in cells fixed 24 hours after exposure. It is suggested that the unconditioned stimulus (electric current) altered the concentration of hormones in the blood, creating an additional block of all the mitotic stages and a lengthening of interkinesis. This created favorable conditions for the repair of potential breaks. (JPRS)

**22744** THYMUS AND BONE MARROW DERIVED LYMPHATIC LEUKAEMIA IN MICE. Haran-Ghera, N.; Peled, A. (Weizmann Inst. of Science, Rehovoth, Israel). Nature (London); 241: No. 5389, 396-398(9 Feb 1973).

It had been established that radiation- and virus-induced lymphatic leukaemias in mice are usually dependent on the thymus, which is probably the target organ for the actual neoplastic transformation. The induction of lymphatic leukaemia in the inbred SJL/J strain of mice by a chemical carcinogen was found not to be thymus dependent, since a high incidence was obtained in thymectomized mice treated with the carcinogen. The lymphocyte origin of radiation-, virus-, and chemical-carcinogen-induced lymphatic leukaemias and lymphosarcomas was analyzed. Full details of the experimental work are given. The thymectomized mice used were given a bone marrow derived lymphocyte population in their lymphoid tissues, and the carcinogen employed was 7,12-dimethylbenzanthracene (DMBA) through a stomach tube. In the radiation experiments the mice were exposed to 550 and 800 rad whole body irradiation followed by DMBA administration. The ability to induce lymphatic leukaemia by a chemical carcinogen in mice devoid of thymus derived lymphocytes was demonstrated, namely leukaemias originating from a bone marrow derived population of lymphocytes. In other studies thymus dependent lymphatic leukaemia was induced by irradiation or a leukaemogenic virus. Immunoglobulin determinants on the surface of lymphoid cells were detected using the direct immunofluorescent technique. The DMBA-induced lymphatic leukaemia in intact or thymectomized irradiated hosts appeared to be of B lymphocyte origin, whereas the radiation and virus induced lymphatic leukaemia was of T lymphocyte origin. These findings are not specific for the SJL/J strain of mice. (UK)

**22745** EFFECT OF IRRADIATION ON THE RELEASE OF LYMPHOCYTES FROM THE THYMUS. Ernstroem, U. (Karolinska Institutet, Stockholm). Acta Radiol., Ther., Phys., Biol.; 11: No. 3, 257-276(Jun 1972).

The thymic release of small lymphocytes in the blood was markedly depressed after both whole body and local thymus gamma irradiation in an experiment using 543 guinea pigs. This was followed by their successively increasing release. The importance of the thymus, even when irradiated, in the regeneration of the spleen and lymph node tissue as well as in immunologic restoration, is discussed. (auth)

**22746** RETENTION OF $^{125}$I GIVEN AS $^{125}$I-5-iodo-2′-DEOXYURIDINE TO MICE AFTER 180 MeV PROTON OR $^{60}$Co GAMMA IRRADIATION. Johanson, K. J. (Univ. of Uppsala). Acta Radiol., Ther., Phys., Biol.; 11: No. 5, 465-471(Oct 1972).

The effect of 180-MeV proton and $^{60}$Co gamma radiation on $^{125}$I retention 20 hrs after $^{125}$IUdR injection was investigated in the whole mouse, the small intestine, and the spleen. The RBE for 180 MeV protons of 1.2 ± 0.3 from previous work seemed to be confirmed. Labeled precursors for diagnostic examinations of cellular proliferation in man are discussed. (auth)

**22747** SURFACE STUDIES OF ACUTE RADIATION INJURY IN THE MOUSE INTESTINE. Carr, K. E. (Univ. of Glasgow); Toner, P. G. Virchows Arch., B; 11: No. 3, 201-210(1972).

The scanning electron microscope was used to follow changes induced by radiation in the surface structure of small intestinal mucosa in mice. Attention is drawn to changes in the surface creases, which are a normal feature of the intestinal villus. There is a progressive disintegration of villous architecture leading finally to gross surface irregularity. The appearances are quite different from those seen in the villous atrophy of human coeliac disease. (auth)

**22748** HAEMOPOIETIC ASPECTS OF THE CHANGES IN THE NATURAL RADIATION RESISTANCE OF MICE AFTER HYPOXIA. Beran, M.; Tribukait, B. (Karolinska Institutet, Stockholm). Acta Radiol., Ther., Phys., Biol.; 11: No. 3, 225-239(Jun 1972).

The contribution of haemopoietic tissue to the increased radiation resistance of the mouse after hypoxia preconditioning was further analyzed. Neither the radiation sensitivity nor the early intracellular repair of the stem cells were improved. The significance of the post-hypoxic polycythemia for the survival of irradiated mice was tested using animals made polycythemic by transfusion. The erythropoietic suppression per se did not influence the survival. Removal of blood from hypoxia preconditioned mice either immediately after hypoxia or after irradiation did not change the radiation resistance. It is suggested that metabolic changes resulting from hypoxia and subsequent readaptation to the ambient pressure affect the processes of proliferation and differentiation of the haemopoietic tissue. (auth)

**22749** PRIMARY BIOCHEMICAL MECHANISM OF RADIATION INJURY. Sopin, E. F. Visn. Kiiv. Univ., Ser. Biol.; No. 14, 3-7 (1972). (In Ukrainian).

The favorable effect on metabolism in radiation injury of the vitamins P-P, folic acid, and vitamin $B_{12}$, as well as choline that take part in the processes of methyl-group synthesis and elimination from the organism is demonstrated. The question of the primary biochemical mechanism in radiation injury is considered from the viewpoint of disturbance of the reactions of normal transport of methyl groups. There is a discussion of the possibility of free methyl radicals appearing first in the organism and then, as a result of this, of nitrogen bases with an altered structure. This results in a distortion of the data transmission process. (JPRS)

**22750** ATTEMPT TO MODIFY THE IONIZING RADIATION INDUCED HISTOPATHOLOGIC EFFECTS ON THE CENTRAL NERVOUS SYSTEM BY RESERPINE ADMINISTRATION. Hariri, N. I.; Aksu, Y.; Falakali, S.; Tuncer, O. I. (Ege Univ., Bornova Izmir, Turkey). Acta Radiol., Ther., Phys., Biol.; 11: No. 4, 341-348(Aug 1972).

Biochemical research in the field of mental illness was greatly stimulated by observation that biogenic amines may serve as neurotransmitters in brain function. A series of experiments was planned to investigate the possible radioprotective actions of psychotropic agents that interfere with the metabolism or action of biogenic amines. Reserpine is supposed to act as a radiation protectant. (auth)

**22751** CHANGES IN THE AVERAGED EVOKED POTENTIALS OF THE RABBIT DURING AND AFTER FRACTIONATED X IRRADIATION. Minamisawa, T.; Tsuchiya, T.; Eto, H. (National Inst. of Radiological Sciences, Chiba, Japan). Electroencephalogr. Clin. Neurophysiol.; 33: No. 6, 591-601(Dec 1972).

The effects of fractionated x irradiation on the averaged evoked potentials (AEPs) to photic stimulation were studied in six adult male rabbits with permanently implanted electrodes. Doses of 300 to 3,000 R, fractionated into 50, 150, and 300 R per day, semiweekly intervals, were administered to the brain. Two hundred evoked potentials were averaged with a CAT 400B. The obtained AEPs were analyzed in terms of the amplitude and peak latency of the five wave components. The results were as follows: The amplitude of the early three components (I, II, and III) of all six animals did not change in any definite direction throughout the observation period. The associated peak latencies were less affected by the radiation. The amplitude of the late two components (IV and V) of all six animals decreased during the 24 h following the first irradiation of 50, 150, and 300 R. The associated peak latencies showed a slight decrease. The changes during the 24 h after the third, sixth, and final exposure were similar to those after the first exposure. The amplitude of the late two components of the four animals irradiated with 1,500 and 3,000 R gradually decreased with increasing doses during fractionated irradiation. One animal irradiated with 300 R also changed somewhat in amplitude at the end of exposure. The associated peak latencies decreased slightly. The amplitude of the late two components of all six animals gradually decreased in the course of time after the end of exposure, with individual variations as to degree. The associated peak latencies showed a slight decrease. The results are discussed in the light of findings by other authors. (auth)

**22752** GROWTH PATTERN OF MICE AFTER GAMMA-IRRADIATION OF NEWBORN. Gajewski, A. K. (Inst. of Hygiene, Warsaw). Nukleonika; 17: No. 12, 663-671(1972).

Inbred mice of A strain were used for testing the growth pattern of mice after gamma-irradiation of newborn animals. Eight hundred male and female mice were randomly divided into experimental groups and irradiated with 4 different doses of gamma rays: 0 (control group), 150, 300 and 450 R. The results indicate that whole-body irradiation of newborn male animals will produce growth impairment due to the slower growth rate that lasts for several months. The growth rate of female mice irradiated as newborn was also decreased but only for 90 days. From that moment the growth rate of irradiated female mice was higher than growth rate of control female mice. Possible mechanisms of growth rate retardation as well as mechanisms responsible for higher growth rate, late in the life of irradiated female mice, are discussed. (auth)

**22753** STUDIES ON ECTOPIC GRANULE CELLS IN THE CEREBELLAR CORTEX: WITH A HYPOTHESIS AS TO THEIR AETIOLOGY AND PATHOGENESIS. Ebels, E. J. (Purdue Univ., Lafayette, IN). Acta Neuropathol.; 21: 117-127(1972).

An attempt was made systematically to produce ectopic cells in the cerebellar molecular layer by means of x irradiation. The influence of the age of the animal at the time of irradiation and the dose of x rays was studied. Based on the results and on data from the literature a hypothesis is put forward as to the mechanism involved. It is suggested that partial destruction of one of the cerebellar matrices is followed by regeneration, which results in a de-synchronization of the morphogenetic events. As a consequence, a numerical mismatching occurs between the ingrowing mossy fibers and the descending granule cells, leading to invasion of the molecular layer by some of the mossy fibers and the formation of ectopic synapases. Dose- and age-dependency of the results of x irradiation are in agreement with deductions from this hypothesis. Similar mechanisms may well be involved in the pathogenesis of other developmental abnormalities of the central nervous system. (auth)

**22754** STUDIES ON ACUTE RADIATION DEATH OF THE MAMMAL EXPOSED TO LARGE RADIATION DOSE. 1. Functional Changes on Central Nervous System Death. Kimura, Y. (Keio Univ., Tokyo). Keio Igaku; 49: No. 2, 131-144(Mar 1972). (In Japanese).

To elucidate the functional changes on the central nervous system by large dose irradiation (more than 10,000 rad), dd-strain male mice, 5 to 6 weeks old, were exposed to x rays of 6 MeV Linear Accelerator. The following results were obtained. At a dose rate of more than 1,360 rad/min, modes of death were divided in three types, central nervous death, intestinal death, and hematopoietic death, according to different doses. Central nervous death of mice was observed in cases exposed to a single dose more than 10,000 rad and the mean survival times were reduced with increasing doses of irradiation to some extent. Higher dose rates showed strong effects on shortening of the life span. As central nervous symptoms, after a period of slowness of motion, there were excitation, convulsive motion, clumsiness and so on, and death occurred after paralysis or spastic seizure. Time lapses of these symptoms are dependent upon total dose of irradiation and the dose rate. (auth)

**22755** OBSERVATIONS ON THE DAILY RHYTHM OF ACID PHOSPHATASE ACTIVITY IN THE MOUSE OVARIES IN NORMAL CONDITIONS AND AFTER IRRADIATIONS WITH UV AND X RAYS. Barbacka, G. (Jagellonian Univ., Krakow). Acta Biol. Cracov., Ser. Zool.; 14: No. 1, 51-58(1971).

Circadian variations in acid phosphatase activity in the corpus luteum of mouse ovaries were observed following exposure to x radiation at 1800 R or to ultraviolet radiation at 80,000 erg/cm$^2$-

sec. Extreme values of acid phosphatase were similar to those observed in the hypothalamus and hypophysics, suggesting similar metabolic processes. (HLW)

### Invertebrates

**22756** OCCURRENCE OF RECESSIVE LETHAL MUTATIONS SUPPRESSED BY Y-CHROMOSOME IN DROSOPHILA MELANOGASTER INDUCED BY X-RAYS AND ETHYL METHANESULPHONATE. Borisov, A. I. (Inst. of Developmental Biology, Moscow). Genetika; 8: No. 11, 83-89(Nov 1972). (In Russian).

The relative efficiency of x-rays and ethyl methanesulfonate (EMS) in inducing mutations in the bobbed locus of Drosophila melanogaster was investigated. After x-irradiation at a dose of 4000 R the frequency of the occurrence of such mutations in relation to the total frequency of sex-linked recessive lethal mutations was 16 times higher as compared with the frequency of such mutations after EMS treatment (the flies were treated with vaporous EMS during 13 hours). The frequency of recessive lethal mutations suppressed by the Y-chromosome after x-irradiation was 6 times higher than after the EMS treatment. All the induced bobbed lethal mutations (7 x-ray induced mutations and 1 EMS-induced mutation) did not show the complementation between each other. The data obtained confirmed the postulated tandem structure of identical cistrons, which composed bobbed-locus controlling rRNA synthesis in D. melanogaster. (auth)

**22757** EFFECT OF IRRADIATION ON THE EMBRYONIC AND POSTEMBRYONIC DEVELOPMENT OF AMIDOSTOMUM ANSERIS (ZEDER, 1800). Phuc, D. V.; Varga, I. (Univ. of Veterinary Science, Budapest). Acta Vet. Acad. Sci. Hung.; 22: No. 2, 197-203(1972).

Eggs of Amidostomum anseris exposed to various doses of gamma rays, ranging from 5 to 160 kilorad, were arrested at different stages of development. In proportion to the dose increase, more and more eggs remained at the stage of an irregular morula showing abnormal cleavage and containing vacuoles. A considerable number of larvae were unable to hatch, whereas others could not cast off completely the cuticle of first and/or second moulting. Irradiation of third stage larvae reduced their infectivity for goslings, resulted in development of sterile females or ones producing infertile eggs, and caused a remarkable shift in worm sex ratio. A significant decrease in the size of worms was also noted. The pathogenic effect of A. anseris can be greatly reduced by exposing the infective larvae to a dose of approx. 40 krad of gamma irradiation. (auth)

**22758** PROMPT DETECTION OF IONIZING RADIATIONS BY CARPENTER ANTS. Martinsen, D. L.; Kimeldorf, D. J. (Oregon State Univ., Corvallis). Biol. Bull.; 143: No. 2, 403-419(Oct 1972).

Carpenter ants exhibited behavioral responses to 10 R/sec (x rays) within one second of the onset of exposure. Within the range of 0.05 to 80 R/sec the strength and duration of responses were proportional to the exposure rate. Latency was inversely related to exposure rate. A comparison of behavioral reactions of normal subjects with subjects whose eyes or antennae had been removed or shielded revealed that sensory receptors (probably olfactory) on the antennal flagella were primarily responsible for detection and led to the onset of prompt responses. Bioelectric potentials were recorded from isolated eyes (electroretinograms) and isolated antennae (electroantennograms) during brief exposures to ionizing radiations. The results largely corroborated evidence derived from behavioral studies that eyes and antennal receptors are sensitive detectors of ionizing radiation. The strength of bioelectric responses varied directly with stimulus strength. Estimates of threshold exposures or doses, delivered in fractions of a second, indicated that the eyes and antennal receptors of the ant can detect x and beta radiations in the millirad dose range. X-ray and visible-light stimuli elicited electroretinograms with very similar characteristics, suggesting a common mechanism of action on the photoreceptor pigment in the ommatidia. The response to beta radiations displayed some unusual characteristics that cannot be explained at present. (auth)

**22759** GENETIC CONTROL OF MOSQUITOES. Kitzmiller, J. B. (Univ. of Illinois, Urbana). Amer. J. Trop. Med. Hyg.; 21: No. 5, 764-771(Sep 1972).

Genetic control of mosquitoes offers a possible ancillary method to traditional types of control. The principal mechanisms available in mosquitoes for genetic control include dominant, recessive, and conditional lethals, behavioral mechanisms, sterility, cytoplasmic incompatibility, hybrid sterility, meiotic drive mechanisms and sex-ratio distorting genes. Cytoplasmic incompatibility, radiation and/or chemically induced male sterility and hybrid sterility were tried in the field on a limited basis. Cytoplasmic incompatibility and chemosterilized male releases have thus far been most successful; the failure of other field trials is largely traceable to the lack of competitiveness of the treated males. Current research in mosquito genetics, which seems to hold the most promise for the future includes salivary gland chromosome studies, hybridization studies, genetic studies of proteins, cytotaxonomy, and translocations. (auth)

**22760** MOLT RECOVERY ON TRANSPLANTING ACTIVATED BRAINS OF RHODNIUS PROLIXUS (HETEROPTERA, REDUVIIDAE) AFTER ARRESTING DEVELOPMENT WITH IRRADIATION. Ben Hamouda, M. H.; Pinet, J. M. (Institut National Agronomique, Paris). Compt. Rend., Ser. D; 275: No. 12, 1259-1262(18 Sep 1972). (In French).

Transplant experiments with irradiated styligenic organs of normal insects demonstrate the sensitivity of the epidermal cells to the hormones of the molt, even after an intermediate radiation dose. On the other hand, brain transplant experiments with permanent Rhodnius larva demonstrate inactivation of the cerebral neurosecreting cells and probably of the prothoracic gland. (France)

**22761** EFFECTS OF X- AND GAMMA-IRRADIATION ON EMBRYO OF THE SILKWORM BOMBYX MORI L. 2. Effect on Larval Growth Observed After Irradiation at Different Developmental Stages. Miki, M. (Saitama-Ken Sericultural Experiment Station, Kumagaya, Japan). Nippon Sanshigaku Zasshi; 40: No. 6, 445-451(Dec 1971). (In Japanese).

To clarify the effects of x rays on larval growth, silkworm embryos at different developmental stages were irradiated with various doses of x rays. The x irradiation was given to developing embryos at 3 day intervals starting from 3rd day after HCl-treatment for hatching, with doses of 0.5 to 2.0 KR at the 3rd day, 1.0 to 3.0 KR at the 6th day and 2.0 to 6.0 KR at the 9th day, respectively. The radiation dose-rate was 200 R/min. The results are as follows: irradiation of the 3rd day embryo brought about a noticeable effect on hatchability, mortality, as well as growth rate of the larvae, even at low doses. Cocoon weight and cocoon shell weight were also markedly affected. The doses required for the same degree of retardation in larval growth were 2 to 3 times as high at the 6th day and more than 4 times as high at the 9th day embryos as those for the 3rd day embryos. An irradiation experiment carried out with a constant dose (1.5 KR) at various developmental stages revealed that the effect of x radiation was severest during early stages before blastokinesis and decreased gradually with the development of the embryo so far as mortality and growth rate were concerned whereas with regard to cocoon weight and cocoon shell weight the most sensitive stage was observed at 60 hours. The latter coincided with the stage of differentiation of the silk gland. The time of appearance and severity of the radiation effect were dependent on radiation dose and the stage of embryonic development. (auth)

## Radionuclide Effects (Internal Source)

### Man

*Refer also to abstracts 22499, 22693, 22707, 22708, 22715, and 22793.*

**22762** (ANL—7960(Pt. 2)) RADIOLOGICAL AND ENVIRONMENTAL RESEARCH DIVISION ANNUAL REPORT, JULY 1971—JUNE 1972. (Argonne National Lab., Ill.). Contract W-31-109-eng 38. 265p. Dep. NTIS.

Separate abstracts were prepared on 21 papers that discuss radium distribution and toxicity in man and related subjects. Seven additional papers discuss methods used in epidemiological studies of normal human populations and physiological studies on man. Abstracts of papers published during the period covered are included. (CH)

**22763** (ANL-7960(Pt.2), pp 1-5) CAUSES OF DEATH IN THE HUMAN RADIUM POPULATION. Failla, P.; Rowland, R. E. [nd].

Radiological and environmental research division annual report, July 1971—Jun 1972.

The frequency of the principal causes of mortality and morbidity and the age at death have been examined as a function of the amount of radium initially acquired in 225 dead cases. Bone tumors and other disabilities typical of radium poisoning occur only at initial burdens above 10 $\mu$Ci/kg skeletal mass. If the cases that exhibited these radiogenic syndromes and symptoms are specifically excluded from the analysis, there appears to be no correlation between initial burden and when or why the remainder of the population died. (auth)

**22764** (ANL-7960(Pt.2), pp 6-22) TIME DISTRIBUTION OF DEATHS OF WOMEN RADIUM DIAL PAINTERS WITH MEASURED BODY BURDENS OF RADIUM. Stehney, A. F.; Lucas, H. F. Jr.; Rowland, R. E. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Actuarial methods for measuring survival rates were tested by analyzing mortality data on women radium dial painters in 5-year intervals after first exposure. It was shown that the criterion of a measured body burden in order to determine life-span as a function of dose had tended to select dial painters who had survived to 1958 or later. Since most of them had been exposed before 1928, there is little information for evaluating survival rates soon after first exposure. For 492 dial painters with initial intake of less than 10 nCi Ra/g bone, only 6 of the total of 35 deaths occurred less than 30 years after first exposure. No differences in the fraction surviving were detected when these dial painters were separated into dosage groups of less than 0.02, 0.02 to 1.0, and 1.0 to 10.0 nCi Ra/g. For 122 dial painters with greater initial intake, 30 of the total of 68 deaths occurred less than 30 years after first exposure, but only 5 of the early deaths occurred among women whose body burdens had been measured while they were alive. (auth)

**22765** (ANL-7960(pt.2), pp 72-84) RATE OF BONE LOSS WITH INCREASING AGE: A COMPARISON OF RADIUM CASES WITH UNEXPOSED INDIVIDUALS. Schlenker, R. A.; Oltman, B. G.; Roth, B. A. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Bone scan data on female radium cases and on normal women, who have had no exposure to radium, have been analyzed and compared. For women over 40 years of age, it was found that the rate at which the mineral mass per unit area in compact bone diminishes with age is significantly greater in radium cases than in normals. Furthermore, the rate in radium cases is significantly higher when the $^{226}$Ra body burden is greater than 0.1 $\mu$Ci, than when it is less than 0.1 $\mu$Ci. (auth)

**22766** (ANL-7960(Pt.2), pp 85-88) CYTOGENIC STUDIES IN PATIENTS WITH A CHRONIC RADIUM BURDEN. Hoegerman, S. F.; Cummins, H. T. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

A study designed to detect chromosomal changes in a large population of radium patients is described. The long-term goal is to determine the nature of the dose-response relationship between $\alpha$ radiation and the frequency with which certain chromosomal aberrations are observed in cultures of circulating lymphocytes. (auth)

**22767** (ANL-7960(Pt.2), pp 231-232) EXPOSURE DATA FOR RADIUM PATIENTS. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Data are tabulated on the radium exposure histories and body burdens of 1,032 human cases under study at the Center for Human Radiobiology. Data are included on the radiation dose to the skeleton calculated to death or to 1971 for the living subjects. (CH)

**22768** (CONF-710847-, pp 63-66) RADIATION DOSIMETRY IN NUCLEAR MEDICINE. Ennow, Klaus (Statens Inst. for Stralehygiejne, Broenshoej, Denmark). 1971. (In Danish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference.

With examples from publications it was demonstrated that the physical data needed for internal dosimetry calculations are already available, and what is more necessary is a collection of more accurate informations of the metabolism of different radiopharmaceuticals. (auth)

**22769** (CONF-710847-, pp 67-72) RADIOPHARMACEUTICALS AND RADIATION PROTECTION OF THE PATIENT. Kristensen, Knud (Sundhedsstyrelsen, Copenhagen). 1971. (In Danish).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

Those radiopharmaceuticals that will give the lowest radiation dose to the patient do often have a short physical half-life. Pharmaceutical problems in relation to preparation and control of these pharmaceuticals are often difficult to solve. If a satisfactory solution of these problems cannot be found, the consequence may be the use of radiopharmaceuticals that will give higher radiation doses to patients. In Denmark, a central radiopharmaceutical service will be established. It is hoped that this service through its radiopharmaceutical work may contribute also to improvement in radiation protection of the patient. A short description is given of the plans for the ISOTOPE-PHARMACY and a discussion is given of present and planned legislation on the use of radiopharmaceuticals. A classification of problems into those related to the quality of radiopharmaceuticals and to those related to the clinical use of radiopharmaceuticals is given. It is found that these problems are of a different nature and may best best be solved separately. (auth)

**22770** (CONF-710847-, pp 73-84) GENETICALLY SIGNIFICANT RADIATION DOSE FROM BRAIN SCINTIGRAPHY AND OTHER CLINICAL ISOTOPE STUDIES. Buechler, F. P.; Haase, J.; Jeppesen, P.; Kalnaes, O. (Radiumstationen, Odense, Denmark). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

At the Radiophysical Laboratory at Odense University Hospital the number of clinical isotope studies increased from 2500 in 1969 to 3400 in 1970, and the figure for 1971 will be approximately 4000. With rising figures it is important to know the genetically significant radiation dose due to these examinations. The age distributions for patients having had brain, liver, and thyroid scintigraphy, renography, and thyroid uptake measurements were calculated, and from these data, obtained by a computer-based registration system, and from general population data, the genetically significant doses were calculated. For brain scintigraphy the genetically significant dose was found to be 0.3 to 0.4 mrads/person/year. For other types of examinations the results are smaller by a factor of about 100. (auth)

**22771** (CONF-710847-, pp 159-176) INHALATION DOSES FROM $^{131}$I AT URBAN SITING. Gyllander, Christina (Aktiebolaget Atomenergi, Studsvik, Sweden). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

Based on concentration statistics and population distribution in an urban area with one million inhabitants, inhalation doses from an iodine release were computed. The calculations include maximum individual doses as well as population doses within a zone of 22 km radius. The evaluation is valid for a power plant at a distance from the center of the city of 2, 5, and 20 km respectively. An exponential formula was used in determining the population distribution. The dispersion, given in terms of relative concentration (s m$^{-3}$), was computed for each 10° sector, several release heights, distances, and sampling periods. By using frequency statistics, concentration values that may be reached or exceeded with a given degree of probability are easily obtained for an actual set of release data during normal operation as well as in accident conditions. (auth)

**22772** (CONF-710847-, pp 253-264) INTAKE OF TRITIUM PRODUCED BY REACTOR IRRADIATION OF $^{3}$He. Ottersen, Ulf (OECD Halden Reactor Project, Norway). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

Helium-3, which was irradiated in the Halden reactor, escaped to the reactor hall when four persons were present. The tritium produced from the $^{3}$He was ca 200 Ci, which distributed in the room. The concentration rose to 40,000 pCi/cm$^{3}$ generally, but with a local peak at the release point where one of the persons was. All persons had left the room within four min from the start of the release. One person received a dose of 4.2 rems, the others considerably less. To explain the doses measured, it was obvious that the tritium had been present partly as HTO. It was found that oxygen had contaminated the helium gas, and that the amount was sufficient to form 10% of the tritium as HTO. (auth)

**22773** (COO-3437-1) STUDY OF NATURAL RADIOACTIVITY IN BRAZIL. Cullen, T. L.; Paschoa, A. S. (Pontificia Universidade Catolica do Rio De Janeiro (Brazil). Instituto de Fisica). Aug 1972. Contract AT(11-1)3437. 55p. (NYO-2577-13). Dep. NTIS.

A review is presented of thorium and thorium daughters as hazardous radioactive substances. The increasing use of thorium in breeder reactors is pointed out; although the level of radioactivity is not high, the long-term effects are most important hazards. Working level units of radon daughters, $^{218}$Po, $^{214}$Pb, and $^{214}$Bi are discussed. A discussion is given of the $^{232}$Th/$^{228}$Th ratio in the natural thorium series and gamma spectra of thorium and its daughters are described. Airborne thorium activity in terms of maximum permissible concentration is discussed and hazards of exposing the lung to the MPD are evaluated. Radioactivity levels were measured at the Guarapari Beach where the monazite sands contain 4 to 6% thorium. Measurements were made on thoron in the exhaled air of three Guarapari inhabitants who had worked in a monazite separation plant from 8 to 17 years. The use of thermoluminescent dosimeters for surveys is reviewed and results of whole-body counting surveys are presented. (HLW)

**22774** (SZS-135) [RADIATION EXPOSURE HAZARDS]. (Staatliche Zentrale Fuer Strahlenschutz, Berlin (East Germany)). Aug 1972. 25p. (In German). Dep. NTIS (U. S. Sales Only).

Separate abstracts were prepared on two papers that discuss the hazards to man from radioisotope release to the environment during reactor accidents. (CH)

*For abstracts of individual papers see: 22775 and 22776.*

**22775** (SZS-135, pp 1-9) CRITERIA FOR PLANNING RADIATION PROTECTION MEASURES IN THE CASE OF HIGH ACTIVITY RELEASES FROM NUCLEAR POWER PLANTS WITH PRESSURIZED WATER REACTORS. Muenchow, W. Aug 1972. (In German).

In radiation exposure hazards.

High-activity releases from reactor accidents at nuclear power plants cannot be excluded completely. In the case of a pressurized-water reactor accident the main hazard to plant personnel and the public in the environment is caused by internal and external exposure to radioiodine, especially $^{131}I$. To avoid radiation exposures exceeding certain emergency dose limits countermeasures are proposed, depending on the individual's dose. Because the applicability of these measures strongly depends on the site conditions and on the probability of accidental releases, guidance can be of general character only. (auth)

**22776** (SZS-135, pp 11-24) INFLUENCE OF COURSE OF ACTIVITY INTAKE ON THE CALCULATION OF INTERNAL RADIATION EXPOSURE. Strauss, H. Aug 1972. (In German).

In radiation exposure hazards.

The influence of course of activity intake on the calculation of internal exposure from monitoring the activity content of the body or of excreta is considered. In calculating the internal exposure from measurement data an approximation method has to be applied, since the course of activity intake into the human body is usually unknown. The greatest deviation of the approximated value from the true value of the internal exposure is given. This deviation is graphically presented as a function of the quotient from the probable period of intake and the effective half-life of the radionuclide in the compartment considered. (auth)

**22777** PULMONARY CHANGES IN REPROGRAPHIC TECHNICIANS DUE TO RARE EARTHS. Menz, M.; Kaufman, E. Z. Unfallmed. Berufskr.; 65: No. 1, 62-73(1972). (In German).

The manufacture and composition of carbon arc-lamp electrodes are described, the composition of the white smoke given off by arc lamps is indicated and the radioactive contamination of reprography workers considered. The development of radiological changes in the lungs is described (focal fibrosis) and the chemical analysis of pulmonary tissue is indicated for 4 technicians who used exclusively carbon-arc lamps for their work for 40 to 50 years. The observed fibrosis are considered to be of occupational origin but cannot state to what extent this fibrosis is due to rare earth dusts or whether some of the damage is attributable to ionizing radiations. (Occup. Saf. Health Abstr.)

**22778** ASSESSMENT OF THYROID INHALATION DOSES IN THE WESTERN UNITED STATES FROM THE CHINESE NUCLEAR TEST OF NOVEMBER 1971. Evans, R. B.; Snelling, R. N.; Buck, F. N. (Western Environmental Research Lab., Las Vegas, NV). AT(26-1)-539. Radiat. Data Rep.; 14: No. 1, 9-15(Jan 1973).

Following a nuclear detonation by the People's Republic of China, measurable increases of radioactivity were detected over the western United States by the Air Surveillance Network, which is operated by the National Environmental Research Center, Las Vegas. The progress and intensity of the radioactive cloud across the United States are presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 0.2 mrem at Scotty's Junction, Nev. (auth)

**22779** CLINICAL AND CYTOGENETIC INVESTIGATION IN CHILDREN OF PARENTS TREATED WITH RADIOIODINE. Einhorn, J.; Hulten, M.; Lindsten, J.; Wicklund, H.; Zetterqvist, P. (Karolinska Sjukhuset, Stockholm). Acta Radiol., Ther., Phys., Biol.; 11: No. 3, 193-208(Jun 1972).

The number of pregnancies and spontaneous abortions were investigated before and after $^{131}I$ therapy in 169 patients. Thirty of the 43 children who were born after the parent had received the treatment were examined clinically and cytogenetically and were compared with controls. (auth) (Sweden)

### Animals

*Refer also to abstract 22481.*

**22780** (ANL-7960(Pt.2), pp 58-61) LOCAL $^{226}Ra$ CONCENTRATIONS AND PLUGGED VASCULAR CANALS IN THE BONE OF A DIAL PAINTER (CASE 01-183). Simmons, D. J.; Ciborowski, L.; Holtzman, R. B. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Vascular damage (plugged osteons) and local concentrations of radium were compared in skeletal remains of a radium dial painter. Results on eight areas of bone with $^{226}Ra$ concentrations in the range of 41 to 155 pCi/g ash showed good positive correlation ($r = 0.79$, $P < 0.01$) up to the maximum represented in our data of about 10% plugged osteons. However, two areas with about 400 pCi/g showed less vascular damage and the smallest percentage of secondary osteons. The data suggest that remodeling of compact bone may be impaired in patients with body burdens in excess of about 0.5 μCi $^{226}Ra$. (auth)

**22781** NATURE OF POSTJUNCTIONAL RECEPTORS. Hu, J. H. (Columbia Univ., New York). Amer. J. Physiol.; 223: No. 4, 882-887(Oct 1972).

The action of $UO_2^{2+}$ (uranyl ion), known to complex with the phosphoryl ligands of cell membranes, was studied in frog sartorius muscle-sciatic nerve preparations in vitro. $UO_2^{2+}$($10^{-5}$ M) caused neuromuscular block wherein prolonged end-plate potentials were recorded at the neuromuscular junction. The sensitivity of the postjunctional membrane (tested by measuring membrane depolarization during microperfusion with carbamylcholine) was found to increase when $UO_2^{2+}$($10^{-8}$ M) was added to the bath. If $UO_2^{2+}$ concentration was increased ($10^{-7}$ to $10^{-5}$ M), postjunctional membrane sensitivity increased transiently and then declined. This transient sensitization did not occur when extracellular $Ca^{2+}$ was raised to $10^{-2}$ M. $UO_2^{2+}$($10^{-7}$ to $10^{-5}$ M) increased and then decreased the rate of rise of the end-plate potentials. A quantitative study of the interaction between $UO_2^{2+}$ ions and carbamylcholine showed that these ions compete for the same binding sites in the membrane. These and other results indicate that postjunctional membrane receptors are phosphate-containing macromolecules. The receptor is considered as a $Ca^{2+}$ complex of a protein and a phosphate-containing macromolecule. (auth)

## Nuclide Kinetics and Toxicology

*Refer also to abstract 22161.*

### Man

*Refer also to abstracts 22160, 22485, 22762, and 22767.*

**22782** (ANL-7960(Pt.2), pp 53-57) HOTSPOT-TO-DIFFUSE RATIOS IN THE BONES OF RADIUM PATIENTS. Simmons, D. J. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

The microscopic distribution of radium in bone is compared with duration of exposure to uptake for 27 radium patients, including 8 cases merely measured for this work. The activity ratios (maximum hotspot to average diffuse) are generally inversely proportional to duration of treatment for medical cases, and a tendency toward smaller ratios with length of employment is seen for radium dial painters. (auth)

**22783** (ANL-7960(Pt.2), pp 62-71) DISTRIBUTIONS OF $^{226}Ra$, $^{210}Pb$, and $^{210}Po$ IN THE LONG BONES OF A RADIUM DIAL PAINTER. Holtzmann, R. B.; Simmons, D. J.; Ilcewicz, F. H.; Gunner, D. L. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Analysis of the distribution patterns of $^{226}Ra$, $^{210}Pb$, and $^{210}Po$ in the long bones of a radium dial painter is given. The $^{226}Ra$ concentrations were fairly constant in the shaft and increased greatly toward the ends. Those in porous bone were generally greater than those in cortical bone. Lead-210 followed its parent $^{226}Ra$ quite well as evidenced by the constancy of ratios of $^{210}Pb$ to $^{226}Ra$ (about 0.3), which were also independent of bone type. In general, $^{210}Po$ was in radioactive equilibrium with $^{210}Pb$, but there was a deficiency of $^{210}$Po in porous bone, which was especially marked in some highly trabeculated regions. (auth)

**22784** (ANL-7960(Pt.2), pp 136-140) RADON BREATH MEASUREMENTS: ESTIMATES OF CORRECTIONS FOR PREVIOUSLY INHALED RADON. Lucas, H. F. Jr.; Markun, F. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

In measurements of the $^{226}$Ra content of living humans by the $^{222}$Rn breath method, a correction must be made for the background radon, which is absorbed into the body from natural environmental sources and released when samples of exhaled air are taken for analysis. This correction would be equivalent to about 20 nCi of emanating radium in the body for typical concentrations of 0.3 pCi of $^{222}$Rn/l of room air, so a preliminary period of breathing air of low radon content is employed when body burdens of less than 1 μCi $^{226}$Ra are to be measured. A group of controls (natural levels of approximately 0.04 nCi expected) was studied in order to determine standard blank corrections. Parameters were adjusted to provide an apparent body burden of about 0.03 nCi as the average for the group and a realistic estimate of the error of individual results. (MCG)

**22785** (ANL-7960(Pt.2), pp 141-148) DO WE NEED TO MEASURE RADON EXHALATION RATES. Rundo, J. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

The correlation between the emanating $^{226}$Ra and the retained $^{222}$Rn contents of 114 patients is examined. There is a considerable spread in the results, and the total radium content can not be predicted unequivocally from the external gamma measurements of retained radon. The possibility of measuring radium directly by external gamma counting is considered. (auth)

**22786** (ANL-7960(Pt.2), pp 149-170) CALIBRATION OF COUNTING EQUIPMENT FOR MEASUREMENTS OF RADIUM IN VIVO. Keane, A. T.; Rundo, J.; Huff, D. R. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

The arc method for determining the amount of a radionuclide in the body by gamma spectrometry was used to estimate the radium C ($^{214}$Bi) burdens of 11 patients with $^{226}$Ra body burdens. Gamma measurements of these persons in the tilted chair yielded a mean calibration factor for this geometry, which is used to determine low levels of radium C in the body. Various parameters affecting the counting efficiency for the chair geometry are discussed. (auth)

**22787** (ANL-7960(Pt.2), pp 180-185) MEASUREMENTS OF $^{226}$Ra IN HUMAN BONES. Essling, M. A.; Keane, A. T.; Huff, D. R. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Bones and bone parts from 20 exhumed human skeletons were assayed for $^{226}$Ra by γ measurement. Results for four cases are tabulated. A correlation is shown between the trabecular/cortical nature of the bone sample and its radium concentration. (auth)

**22788** (ANL-7960(Pt.2), pp 186-196) MEASUREMENTS OF $^{210}$Pb AND $^{210}$Pb/$^{226}$Ra RATIOS IN HUMAN BONE IN VITRO. Eckerman, K. F.; Rundo, J. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Measurements are reported of the concentration of $^{210}$Pb and of the $^{210}$Pb/$^{226}$Ra ratio in human bone samples, from individuals with $^{226}$Ra burdens using the techniques of gamma spectroscopy. The methodology for the determination of the $^{210}$Pb/$^{226}$Ra ratio without direct evaluation of the corresponding activities is outlined, and the implication of this procedure is discussed. (auth)

**22789** (ANL-7960(Pt.2), pp 197-205) ROTOSCANNER FOR THE MEASUREMENT OF LOW LEVELS OF RADIOACTIVITY IN IRREGULARLY SHAPED SAMPLES. May, H. A.; Rundo, J.; Keane, A. T. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

A bone or other human tissue sample is rotated at 2 rpm between two large NaI(Tl) detectors which move up and down along the length a preset number of times. In this way the effects on the detection efficiency of different distributions of radioactivity in different samples of various size are greatly reduced without much loss of sensitivity (limit of detection in bones of a few tens of picocuries of radium-226). However, there is a need for a more accurate method of calibration than that so far investigated. (auth)

**22790** (ANL-7960(Pt.2), pp 222-226) RADIUM LEACHING FROM BONE. Farnham, J. E.; Rybicki, K. A.; Sha, J. Y. [nd].

Radiological and environmental research division annual report, July 1971–Jun 1972.

Samples of compact cortical bone and trabecular bone, containing a large amount of $^{226}$Ra activity, were allowed to soak in neutral 10% formalin or 95% ethanol fixative solutions for periods of 1 to 7 days. The solutions were analyzed for radium in order to determine the amount of Ra that was leached from the bone. These data indicate that there is less than 0.01% loss of Ra from bones soaked for one day in formalin or for 7 days in ethanol. However, care should be taken to neutralize the formalin because formalin at pH 5.9 leached a much larger fraction of the radium from bone. (auth)

**22791** (BNWL-SA-4206) CONCENTRATIONS OF $^{65}$Zn IN MARINE FOODSTUFFS AND PACIFIC COASTAL RESIDENTS. Essig, T. H.; Endres, G. W. R.; Soldat, J. K.; Honstead, J. F. (Battelle Pacific Northwest Labs., Richland, Wash.). Mar 1972. Contract AT(45-1)-1830. 27p. (CONF-720708-14). Dep. NTIS $3.50.

From Symposium on the interaction of radioactive contaminants with the constituents of the marine environment; Seattle, Washington, USA (10 Jul 1972).

A study was made of the content of $^{65}$Zn in people living in two coastal communities in Oregon and Washington in the spring of 1970 and the fall of 1971, and the relationship between their body burdens and their seafood intake. Both communities are near the mouth of the Columbia River where measurable concentrations of $^{65}$Zn had been found in locally obtained seafoods (crab, mussels, oysters, and shrimp). The second study was conducted to determine the effects of the shut-down of the older Hanford production reactors early in 1971 on the content of $^{65}$Zn in the same individuals examined in 1970. Zinc-65 content was determined by the whole-body counting. Diet information included the size of each shellfish serving consumed and the method of culinary preparation used. Samples of seafood obtained locally during the study periods were also analyzed for $^{65}$Zn content. A total of 462 subjects contributed diet information and were measured in the whole-body counter during the first study and 169 of these participated in the second study. A decrease in $^{65}$Zn concentration was quite obvious after the reactor shut-down. The ratios of measured-to-calculated $^{65}$Zn body burdens gave good agreement. (CH)

**22792** (CONF-710847-, pp 285-298) ELIMINATION RATE OF $^{137}$Cs IN INDIVIDUALS AND IN THE CONTROL GROUP. Suomela, Matti (Inst. of Radiation Physics, Helsinki). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

The biological half-life of $^{137}$Cs was measured in a group of two women and three men who were given smoked reindeer meat. The amounts of meat eaten varied from 1.1 to 1.4 kg and the $^{137}$Cs amounts ingested in the meat ranged from 27 to 74 nCi. The biological half-lives were determined from whole-body counter measurements and were 61 and 65 days for women and 60, 73, and 80 days for men. Changes in the $^{137}$Cs level in the control group of the Institute of Radiation Physics were followed since the end of 1965 when the maximum value, 182 pCi/g, for the $^{137}$Cs/K ratio was found. The values of the $^{137}$Cs/K ratios decreased thereafter at an average rate of 31% a year up to the beginning of 1969; after then the decrease was only 14% a year. Ten women and sixteen men belonged to the control group. Details of both measurement series are given. (auth)

**22793** (CONF-710847-, pp 299-308) BODY BURDEN OF $^{137}$Cs AND RADIATION DOSE IN FINNISH LAPPS. Rahola, T.; Miettinen, J. K. (Univ. of Helsinki). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

The long-life fission product $^{137}$Cs is largely accumulated in slowly growing lichens and is transferred to man by the foodchain lichen–reindeer–man. Since 1961, the $^{137}$Cs burdens of Finnish Lapps have been measured every spring (also in autumn 1962 and 1969) by using a truck-installed whole-body counter. The highest $^{137}$Cs whole-body burdens were found in March 1965, when the highest individual value was 3 μCi/man. The average for the most exposed group of male reindeer herders in March 1965 was 1.5 μCi per man. In March 1971 the highest individual value was 0.9 μCi per man and the average for the group of male reindeer herders 0.5 μCi. From 1965 until 1969 there was a rapid decrease in the body burdens. The leveling of the decrease after 1969 is probably mainly caused by the Chinese nuclear tests in the atmosphere. In 1970 and 1971, the annual radiation dose of reindeer herders from $^{137}$Cs was estimated to be about 60 mrads/

yr. The integrated dose to the present generation of reindeer herders (1955 to 1985) from tests carried out before 1963 was estimated to be about 1 rad/30 yrs per man. (auth)

**22794** (CONF-710847-, pp 339-345) EXPERIENCES WITH INHALATION OF RADIOACTIVE IODINE IN ISOTOPE PRODUCTION LABORATORIES. Garder, Karen (Institutt for Atomenergi, Kjeller, Norway). 1971. (In Norwegian).

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

From the data of air monitoring and measurements of radioactive iodine in the thyroid gland an analysis was made showing the correlation between these two quantities. The amount of monitoring needed for adequate personnel surveillance, and especially for making reliable thyroid dose estimations, is discussed. (auth)

**22795** (FRNC-CONF-64) CHOICE OF RADIOISOTOPES FOR SYNOVIORTHESIS. Ingrand, J. (Hospital Cochin, Paris (France)). 1971. 8p. (In French). (CONF-710563-4). Dep. NTIS. (U. S. Sales Only).

From Meeting on radioisotope synoviotherapy (synoviorthesis); Paris, France (26 May 1971).

The characteristics of radioisotope preparations used in the treatment of rheumatoid disease are discussed, reference being made to the possibility of energy transfer to tissues other than those of the bone joint. The principal characteristics of colloidal preparations of rare earths ($^{90}$Y, $^{169}$Er, and $^{186}$Re), and $^{198}$Au used for this purpose, are reviewed. The extent to which the migration of the radioactivity affects tissue outside the articulatory cavity is discussed. The results of previous observations indicate that the absence of migration in a particular patient should be verified by a preliminary tracer dose of the preparation to be administered for therapy. The choice of the colloidal radioactive preparation used depends upon the age and sex of the patient and the articulation to be treated. (France)

**22796** (LA-4875) PLUTONIUM IN AUTOPSY TISSUE. Campbell, E. E.; Milligan, M. F.; Moss, W. D.; Schulte, H. F.; McInroy, J. F. (Los Alamos Scientific Lab., N. Mex.). Jan 1973. Contract W-7405-eng-36. 47p. Dep. NTIS.

Since 1959, selected tissues from deceased humans have been examined for the presence of plutonium. The original purpose was to correlate $^{239}$Pu body burden of personnel calculated from urine assay and actual burden determined by analysis of autopsy materials. The tissues have provided data on plutonium deposition in man resulting from general distribution of plutonium in the environment through global fallout and that resulting from plutonium fabrication or research and development operations. Lung, liver, kidney, lymph, and skeletal tissue are the principal materials examined. The analytical data, the significance of the findings, and the considerable uncertainties in the radiochemical analysis and calculations are discussed. The results are contained in the appendixes to this report. Median concentrations in the organs and tissues of a general population (not occupationally exposed) were (each number represents dis/min Pu per kg): liver, 1.4; lung, 0.8; lymph nodes, 3.0; bone, 0.6; and kidney, 0.6. Plutonium concentration is generally higher in the tissues of those who have been occupationally exposed to plutonium; the concentration obviously depends upon the nature of the exposure and its severity and duration. (auth)

**22797** (RFP-1849) DISTRIBUTION OF PLUTONIUM AND AMERICIUM IN OCCUPATIONALLY EXPOSED HUMANS AS FOUND FROM AUTOPSY SAMPLES. Lagerquist, C. R.; Hammond, S. E.; Bokowski, D. L.; Hylton, D. B. (Dow Chemical U.S.A., Golden, Colo. Rocky Flats Div.). 1 May 1972. 12p. (CONF-720614-6). Dep. NTIS.

From 17th annual meeting of the Health Physics Society; Las Vegas, Nevada, USA (12 Jun 1972).

Nineteen cases are discussed where tissues were obtained from autopsy and analyzed radiochemically for plutonium and americium. Distribution patterns varied greatly from case to case, depending on the mode of entry, the chemical form, the length of time since exposure, and perhaps many other parameters as well. A typical distribution was not found, but on the average the lung and tracheal-bronchial lymph nodes had the highest concentration of material followed by the liver, the bones, and finally the other tissues. (auth)

**22798** TOXICOLOGICAL STUDIES INVOLVING TRACE ELEMENTS. Parizek, J. (Inst. of Physiology, Prague). pp 177-194 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425-.

Problems of toxicity of compounds of certain trace elements exceeded limits of geochemically or professionally limited exposure. In addition to the methods necessary for determining concentrations and chemical forms of trace elements present in the organism and environment, the evaluation of possible hazards depends on sufficient knowledge of the biological effects of trace elements and of those factors of the external and internal environments that can influence the response of the organism to their presence. Interrelations between certain trace elements are of practical importance from the aspect of analytical methods including activation analysis, but also from the aspect of effective preventive and therapeutic measures. The newly discovered interrelations are discussed, including those between inorganic and organic compounds of selenium and mercury. (auth)

**22799** DATA. SECTION IV. OTHER DATA. Radiat. Data Rep.; 14: No. 1, 47-57 (Jan 1973).

Data are presented on the content of $^{90}$Sr in human bone samples collected throughout the USA during October through December 1971. Data are included on levels of radioactivity in environmental samples collected in the environs of Knolls Atomic Power Laboratory, Schenectady, N. Y., during 1970 and in the environs of Mound Laboratory, Miamisburg, Ohio during January through June 1970. (CH)

**22800** BIOLOGICAL HALF-LIFE OF $^{137}$Cs IN TEENAGERS. Pietrzak-Flis, Z. (Central Lab. for Radiological Protection, Warsaw). Nukleonika; 17: No. 10, 547-554(1972).

On the basis of long-term control of the intake of $^{137}$Cs and its body burden, approximate values of the biological half-life, $T_b$, of $^{137}$Cs, were estimated on a group of teenagers aged 15 to 19 yrs. The mean value of $T_b$ found was 112 ± 8 days, the mean value in boys being about 1.5 times higher than in girls. (auth)

**22801** RELATIONSHIP BETWEEN THE CONCENTRATION OF $^{137}$Cs IN MILK AND MAN. Marshall, D. H.; Burkinshaw, L. (Leeds General Infirmary, Eng.). Nature (London); 240: No. 5383, 571-572(29 Dec 1972).

Cesium-137 is detectable in most dietary components, but the chief sources are milk and dairy produce, and an attempt was made to relate the concentration in man to that in milk; this should be satisfactory for extrapolation to the remainder of the diet provided the variation in milk with time approximately parallels analogous variations in the remainder of the diet. Concentrations in milk in the UK are published as mean quarter-year values, and these values were taken to be true for mid-quarters, values at other times being calculated by linear interpolation. Assuming that the dietary intake rate of $^{137}$Cs is proportional to its concentration in milk an expression is derived for the concentration in the body, using a single compartment model. Measured body levels of $^{137}$Cs in men and women for the period 1967 to 1970 are shown tabulated. Comparisons are made in the data for men and women, and it is found that women appear to have a lower dietary intake of $^{137}$Cs. (UK)

## *Animals*

*Refer also to abstract 22164.*

**22802** (ANL-7960(Pt.2), pp 41-47) COMPARATIVE AUTORADIOGRAPHY OF $^{45}$Ca AND $^{133}$Ba IN BEAGLES. Groer, P. G.; Marshall, J. H.; Farnham, J. E.; Rabinowitz, S. A. [nd].

Radiological and environmental research division annual report, July 1971-Jun 1972.

Measurements of the surface activity on nongrowing bone surfaces and of the diffuse activity in beagles injected with $^{45}$Ca and $^{133}$Ba were made. A method to quantitate measurements of $^{133}$Ba surface activity is described. On bone surfaces, a factor of 4 preference for Ba as compared to Ca was found on endosteal surfaces. (auth)

**22803** (ANL-7960(Pt.2), pp 48-52) HOTSPOT-TO-DIFFUSE RATIO IN MULTIPLE INJECTION RADIUM DOGS. Groer, P. G.; Marshall, J. H.; Simmons, D. J.; Rabinowitz, S. A.; Goldman, M. [nd].

Radiological and environmental research division annual report, July 1971-Jun 1972.

Measurements of the optical hotspot and diffuse densities on autoradiographs of canine bone are being made to determine if the rate of diminution in the diffuse component and in hotspots is the same. The dogs were sacrificed serially after receiving multiple injections of $^{226}$Ra. The data obtained so far seem to indicate that the hotspot density decreases faster than the diffuse density in cortical bone. In cancellous bone the rates of diminution seem to be identical. (auth)

**22804** (BNWL-SA-4214) RELATIONSHIPS BETWEEN THE SIZE DISTRIBUTION OF $^{239}PuO_2$ AEROSOLS, AEROSOL CONCENTRATION AND NEBULIZER SUSPENSION CONCENTRATION. Craig, D. K.; Buschbom, R. L.; Herring, J. P. (Battelle Pacific Northwest Labs., Richland, Wash.). 1972. Contract AT(45-1)-1830. 24p. (CONF-720614-7). Dep. NTIS $3.25.

From 17th annual meeting of the Health Physics Society; Las Vegas, Nevada, USA (12 Jun 1972).

In a study of low-level effects of inhaled $^{239}PuO_2$ in beagle dogs, alveolar burdens over the 1500-fold range from 2 nCi to 3 $\mu$Ci were deposited in unanesthetized dogs by aerosol inhalation. Aerosols were generated by nebulizing magnetically stirred suspensions of $^{239}PuO_2$ particles in water; the aerosol concentration (CONC) being varied, primarily, by changing the Pu concentration of the suspension (SSA). If the mass concentration of the suspension was kept below about 10 mg (540 $\mu$Ci) $PuO_2$/ml, a good correlation ($R = 0.827$ for $n = 64$) was observed between CONC and SSA with constant air flow through the exposure chamber. SSA values from 1 to 600 $\mu$Ci/ml gave CONC values in the range 1.5 to about 3000 nCi/l. However, the aerodynamic equivalent size distribution also varied significantly with CONC. The activity median aerodynamic diameter (AMAD) increased from about 1.5 to 3$\mu$m as CONC increased ($R = 0.786$ for $n = 64$), while the geometric standard deviation (GSD) decreased ($R = 0.576$ versus AMAD). (auth)

**22805** (EUR-4900) CHRONIC TOXICITY OF A MIXTURE OF ALKYLATED NAPHTHALENES USED AS A NUCLEAR REACTOR COOLANT. Ott, H.; Gerbaulet, K.; Pirrwitz, D. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Feb 1973. 14p. Dep. NTIS (U. S. Sales Only). EUR B.Fr. 40,-.

The effects of chronic administration to rats of a nuclear reactor coolant, THERMIP, a commercial mixture of alkylnaphthalenes, are reported. The animals were treated with a daily inhalation dose of about 0.3 mM/kg body weight for 5 months. At the end of the period histological examinations, as well as a series of biochemical tests, did not reveal pathological damage. Prolonged ingestion of alkylnaphthalenes caused an induction of drug metabolizing enzymes in the liver, as made evident by the pentobarbital sleeping time test. (auth)

**22806** (ORNL-tr-2669) BIOCENOTIC PATTERNS OF $^{90}Sr$ AND $^{137}Cs$ TRANSFER IN VARIOUS LINKS OF THE FOOD CHAINS. Il'enko, A. I. Translated from Zh. Obshch. Khim.; 31: No. 6, 698-708(1970). 14p. Dep. NTIS $3.00.

Studies were made on $^{90}Sr$ and $^{137}Cs$ migrations in different links of food chains and their distribution from prey to predators (predatory fishes, reptiles and mammals); the content of $^{90}Sr$ increased and that of $^{137}Cs$ decreased in some tissues of mammals and phytophagous and insectivorous birds as compared with those in food. During the migration of these tracers from prey to predators (predatory fishes, reptiles and mammals) the content of $^{90}Sr$ and $^{137}Cs$ in the skeleton and muscles of the latter increases. The amount of $^{137}Cs$ in muscles of predatory birds is lower than in the rodents on which they feed and that of $^{90}Sr$ in the bone tissue of predators is lower than in prey skeleton. Differences in the content of tracers in various links of food chains in the biocoenosis are due to ecological and morphological differences between the organisms. The amount of tracers varies in animals that differ in the character of feeding. (auth)

**22807** REMOVAL OF PLUTONIUM FROM MOUSE LIVER BY GLUCAN AND DTPA. Rosenthal, M. W.; Brown, H.; Chladek, D. L.; Moretti, E. S.; Russell, J. J.; Lindenbaum, A. (Argonne National Lab., IL). Radiat. Res.; 53: No. 1, 102-114(Jan 1973).

Glucan from yeast is additive with DTPA (diethylenetriaminepentaacetic acid) in removal of polymeric plutonium-239 from the mouse liver. At 47 days after administration of plutonium, the net removal was 8.5% of the injected dose by glucan alone, 11.5% by twice-weekly DTPA treatments, and 19.5% by combined therapy. A 60 mg/kg dose of glucan, given intravenously, was equally effective when given in a single injection, divided into three daily injections, given 5 days or 3 hr before plutonium, or 5 days after plutonium. A 15 mg/kg dose of glucan was almost as effective as higher doses (30-120 mg/kg). Hepatic plutonium removed by glucan was excreted in the urine in the presence of DTPA, or was apparently translocated to the skeleton without DTPA. As shown earlier for monomeric plutonium in the mouse, liver deposits of polymeric plutonium are excreted primarily through the feces, both with and without DTPA, and skeletal deposits removed by DTPA are excreted through the urine. Twice-weekly injections of 100 or 500 mg/kg of DTPA are equally effective in removal of polymeric plutonium from mouse bone and liver, also confirming results with monomeric plutonium. (auth)

**22808** FACTORS INFLUENCING THE ELIMINATION RATE OF $^{133}Xe$ INJECTED INTRACUTANEOUSLY. A Study on Rats. Palmer, B. (Karolinska Sjukhuset, Stockholm). Scand. J. Plast. Reconstr. Surg.; 6: No. 1, 1-5(1972).

Xenon-133 clearance was used for cutaneous perfusion measurements on rats. A study is presented in which some factors influencing the clearance are analyzed. The mean clearance value for a group of five animals was almost constant when followed during a period of two to three weeks. The depth of anaesthesia influenced the clearance. The clearance was somewhat lower when the injected volume was increased. Local injection of the vasoconstrictors noradrenaline and felypressin caused a distinct lowering of the clearance, whereas this was enhanced by body heating. Available evidence makes the use of the present $^{133}Xe$ clearance method possible for elucidating variations in the blood flow in circumscribed areas where a direct method of measurement is difficult to apply. (auth)

**22809** CHANGES IN THE ACTIVITY OF SOME ENZYMES IN BLOOD AND LIVER OF RABBITS, TREATED WITH SMALL DOSES OF URANYL NITRATE AND SULFURATED APRICOTS. Markova, M.; Rasev, Z. Khig. Zdraveopazvane; 15: No. 1, 67-78 (1972). (In Bulgarian).

Changes in the activity of liver (indicator, secretory, and excretory) enzymes were dynamically followed characterizing cirrhotic changes in liver of rabbits, treated with uranyl nitrate (0.10 mg/kg body weight for 60 days) and sulfurated apricots (10 gm per an animal for 180 days) for a period of 180 days. There was a phasic activity of the examined ten enzymes in blood and liver. At the initial stage of the examination there was an increase in the activity of catalase, transaminases (GOT and GPT), lactate dehydrogenase, sorbate dehydrogenase, and guanase in blood serum. In the blood serum there was a reduction in the activity of alkaline phosphatase, aldolase, cholinesterase and ornithine-carbamyltransferase. In liver the activity of all examined enzymes was increased except that of catalase, aldolase, and cholinesterase, whose activity was reduced. The obtained changes in the enzymic activity at the end of the experimental period did not reveal changes characteristic of liver cirrhosis except that of alkaline phosphatase. High increase of the specific liver enzymes (guanase and ornithinecarbamyltransferase), not examined in uranium intoxication, is an early and sensitive test for uranium damage. The results are of interest as regards the changes in the activity of the examined enzymes in the groups of animals fed sulfurated apricots. They do not differ from those changes in the activity of enzymes in animals, treated with uranyl nitrate. Additional experimental studies for finding out a component with toxic action in sulfurated apricots seem necessary. (Abstr. Bulg. Aci. Med. Lit.)

**22810** EFFECT OF HEAVY WATER ON THE ISOTOPIC RATIO $^{13}C/^{12}C$ OF $CO_2$ EXHALATED BY RATS. Mosora, F. Rev. Roum. Biol., Ser. Zool.; 17: No. 1, 69-71(1972). (In French).

The isotopic ratio $^{13}C/^{12}C$ (expressing per mil differences from a standard) of $CO_2$ exhaled by rats showing symptoms of deuterium intoxication increases by 40% in the period of high metabolic rate falls below normal. The results obtained demonstrate that the changes of this isotopic ratio are due to the modifications induced by heavy water in the metabolic rate. (auth) (Rom. Sci. Abstr.)

**22811** REDUCTION IN STRONTIUM ABSORPTION IN PREGNANT, LACTATING, AND SUCKLING RATS. Kostial, K.; Gruden, N.; Durakovic, A.; Juvancic, V.; Simonovic, I. (Univ., Zagreb). Acta Radiol., Ther., Phys., Biol.; 11: No. 3, 277-287(Jun 1972).

The absorption of oral radioactive calcium and strontium was determined during the earlier and later stages of pregnancy and lactation in rats. A gradual increase in their absorption from the gut occurred, maximum values being reached at the end of lactation. The addition of alginates to the milk of newborn rats, fed artificially, decreased the absorption of strontium without affecting that of calcium. (auth)

**22812** RADIOLABELLING OF DROSOPHILA EMBRYOS. Sayles, C. D.; Procunier, J. D.; Browder, L. W. (Univ. of Calgary, Alberta). Nature (London) New Biol.; 241: No. 111, 215-216 (14 Feb 1973).

A simple technique is described whereby Drosophila melanogaster impermeable embryos were collected in gram lots, dechlorinated with 4.6% sodium hypochlorite, dewaxed with Triton X-100 anionic detergent, and made to assimilate radioisotopically labeled precursor molecules in aqueous media, without significant loss of viability. Incorporation of $^3H$-irridine into RNA by dechlorinated-dewaxed embryos was considerably higher than in controls. (UK)

### *Plants*

*Refer also to abstract 22500.*

**22813** INVESTIGATIONS ON THE UPTAKE OF RADIOACTIVE ELEMENTS BY KALE FROM SOIL AND ATMOSPHERE AND ATTEMPTS OF DECONTAMINATION. Rohleder, K. (Staatliche Chemische Untersuchungsamt, Brunswick). Z. Lebensm. Untersuch. Forsch.; 149: No. 4, 223-227(1972). (In German).

The uptake of $^{90}$Sr, $^{137}$Cs, and $^{95}$Zr by kale and attempts at decontamination are investigated. The surface of the leaves mainly takes up $^{95}$Zr and $^{137}$Cs, the roots $^{90}$Sr. Apparently, the uptake of $^{137}$Cs and $^{90}$Sr from soil follows the amount of precipitation. In spite of treating kale-leaves with hot water for some time, decontamination is possible only to a small extent. (auth)

## New Tracer Techniques

*Refer also to abstracts 22041, 22626, and 22734.*

**22814** (AAEC/TM-616) MOVEMENT OF PHOSPHORUS IN THE LITTLE RIVER ESTUARY, NEW SOUTH WALES. Giles, M. S. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Oct 1972. 21p. Dep. NTIS (U. S. Sales Only) $3.25.

The estuary of the Little River, N.S.W. was mapped and measurements made of phytoplankton productivity, phosphorus content, chlorophyll content, zooplankton biomass, salinity, temperature, and oxygen content. Phosphorus-32 and tritium were injected into the estuary and the rate of movement of $^{32}$P into the phytoplankton and zooplankton was calculated. The turnover time for $^{32}$P in solution was approximately two hours. (auth)

**22815** (ANL-7960(Pt.2), pp 38-40) DIFFUSION MODEL FOR THE LONG-TERM EXCHANGE OF $^{45}$Ca ACTIVITY IN HUMAN BONE. Groer, P. G.; Rabinowitz, S. A.; Marshall, J. H. [nd].

Radiological and environmental research division annual report, July 1971—Jun 1972.

Radial diffusion from canaliculi outward into the surrounding calcified matrix seemed to be a possible mechanism for the formation of the diffuse component in a mammalian bone according to preliminary calculations by Marshall et al. An exact solution of the diffusion equation for the region between two concentric cylinders representing the extracanalicular territory is given. The calculated $^{45}$Ca diffuse activity in man is in good agreement with the observed activity. (auth)

**22816** (FOA-4-4528-A-3) TRANSFER OF SIMULATED FALLOUT PARTICLES FROM PASTURE TO GRAZING DAIRY CATTLE. II. EXPERIMENTS WITH WET DEPOSITED 43 TO 60 AND 100 TO 200 $\mu$m PARTICLES. Ekman, L.; Eriksson, A.; Greitz, U. (Forsvarets Forskningsanstalt, Stockholm (Sweden)). Feb 1973. 13p. Dep. NTIS (U. S. Sales Only).

The transfer of simulant close-in particulate fallout from pasture to grazing cows was studied in six field experiments. The experiments were performed with wet deposited 40 to 63 and 100 to 200 $\mu$m particles labelled with $^{141}$Ce and $^{140}$La, respectively. The fraction of the deposition ingested by the animals was assessed by assay of the radioactivity content in feces. On the average 18 (range 6 to 39) and 21 (range 6 to 27) per cent, respectively, of the smaller and larger particles deposited were consumed by the grazing cows. Attempts were also made to estimate the fraction of deposited particles consumed by the cows by measurements of $^{141}$Ce and $^{140}$La in grass samples taken before and after grazing. The measurements show that it is very difficult to sample grass in a manner similar to the way cows graze. (auth)

**22817** CONTAMINATIONS INDUCED BY COLLECTION OF LIVER BIOPSIES AND HUMAN BLOOD. Versieck, J. M. J.; Speecke, A. B. H. (Univ., Ghent). pp 39-49 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425—.

A study was undertaken about possible contaminations during the collection of human blood and liver biopsies for the determination of trace elements. Disposable needles for venipuncture, disposable surgical blades, and Menghini needles for percutaneous liver biopsy were irradiated in a nuclear reactor to obtain a high specific activity of the different elements in the instruments. Conditions for collecting human blood and liver biopsies were simulated in vitro. Successive blood samples of about 20 ml were collected by puncturing a plastic tube filled with blood at 37°C, using the irradiated needles. Liver biopsies were taken with the radioactive surgical blades or Menghini needles. To determine contaminations by manganese and copper, samples handled with instruments irradiated at a flux of $8 \times 10^{11}$ n cm$^{-2}$ s$^{-1}$ for 6 h, were counted as soon as possible after the end of the irradiation on a NaI(Tl) detector coupled to a 400-channel analyzer. Other samples, handled with instruments irradiated at a flux of $5 \times 10^{13}$ n cm$^{-2}$ s$^{-1}$ for 5 days, were counted on a high-resolution Ge(Li) detector coupled to a 4096-channel analyzer at different intervals during the six months period following the irradiation. The spectra obtained were qualitatively and quantitatively analyzed by an adequate computer program. In the experimental conditions, the radioactivity passed into the various biological samples represents possible contaminations. The values, converted into ppM, were compared with data given in the literature for the concentrations of trace elements in normal human serum and liver tissue. During the collection of blood, contaminations of manganese, copper, chromium, iron, nickel, cobalt, zinc, and tantalum occur. The contaminations are the largest in the first 20 ml flowing through the needle. Whereas contaminations of copper and zinc are negligible, those due to manganese are quite frequent and the induced concentrations are important when compared with the manganese concentration in normal human serum. Contaminations of 0.5 to 0.7 parts per billion ($10^9$) were obtained, the concentration of Mn in normal serum being approximately 0.6 ppB ($10^9$). Iron contamination reaches about 5 to 10% of the normal Fe concentration in serum. In liver biopsies taken with irradiated surgical blades, contaminations of manganese, copper, scandium, chromium, iron, nickel, cobalt, zinc, silver, antimony and gold were found. The calculated concentrations usually remain low in comparison with the concentrations in normal human liver tissue. Contaminations induced by taking liver biopsies with a Menghini needle are much larger: they can exceed concentrations in normal human liver tissue. For cobalt, contaminations up to 0.24 ppM were found while in the literature values of approximately 0.06 to 0.20 ppM (wet tissue) are given as a normal concentration. For chromium contaminations up to about 4 ppM were found. Thus, the use of this sampling method is unreliable for determinations of certain trace elements. (auth)

**22818** SOME ASPECTS OF SELENIUM METABOLISM IN RATS. Maziere, M.; Comar, D. (Service Hospitalier Frederic Joliot, Orsay, France). pp 359-372 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972). (In French).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425—.

The occupancy principle described by Orr and Gillespie and activation analysis were used to measure the absorption coefficient and total content of selenium in rats. Several batches of rats restricted in movement and subjected to varied diets of selenium were given a tracer dose of selenium-75 ($Na_2SeO_3$) by injection or orally. The radioactivity of the whole body and the specific radioactivity of the blood selenium were kept under observation for 2 to 3 months, depending on the batch concerned. The determination of stable selenium was carried out by means of destructive or nondestructive radioactivation, depending on the type of sample. The areas generated by the curves for the whole-body radioactivity ($\theta$) and for the total blood ($\theta'$) extrapolated for an infinite period of time represent the selenium occupancy of the various compartments. When the blood concentration of the stable selenium ($C'$) is known, the total amount of natural selenium in the organism ($C$) is represented by the relationship: $\theta/C = \theta'/C' = 1/F$, F representing flux of selenium into the system, i.e., daily diet, when the tracer is administered orally. The absorption coefficient was deduced from experiments carried out after the injection and ingestion of the tracer. The results obtained by this kinetic method were checked after sacrifice of the animals, determinations being carried out by means of the activation of homogenates of whole rats and of various organs. (auth)

**22819** TRACE ELEMENTS IN RELATION TO CARDIOVASCULAR DISEASES; THE WHO/IAEA JOINT RESEARCH PROGRAMME. Masironi, R. (World Health Organization, Geneva). pp 503-516 of Nuclear Activation Techniques in the Life Sciences, 1972. Vienna; International Atomic Energy Agency (1972).

From Symposium on nuclear activation techniques in life sciences; Bled, Yugoslavia (10 Apr 1972). See CONF-720425—.

Death rates from cardiovascular diseases show different geographical patterns and increasing temporal trends. The relationship between trace elements and cardiovascular diseases is reviewed. Certain elements, e.g., Cr, Cu, F, Mn, Si, V, and Zn, seem to exert beneficial effects on the cardiocirculatory function while others like Cd, Co, Pb, may have detrimental effects. Studies showing an inverse association between hardness of drinking water and cardiovascular death rates are reviewed. The association may be due to the fact that soft waters lack the beneficial elements present in hard waters, or extract harmful elements from pipes. Certain associations were found also between the chemical composition of rocks and soils and cardiovascular death rates. The scope of surveys of the relationships is outlined. (auth)

**22820** QUALITATIVE AND QUANTITATIVE ANALYSIS OF REDUCING CARBOHYDRATES BY RADIOCHROMATOGRAPHY ON ION-EXCHANGE PAPERS. Conrad, H. E. Sr.; Varboncouer, E.; James, M. E. (Univ. of Illinois, Urbana). Anal. Biochem.; 51: No. 2, 486-500(Feb 1973).

A highly specific method for qualitative and quantitative analysis of reducing carbohydrates is described. The method involves the measurement of the amount of tritium found in [$^3$H] sodium borohydride-reduced sugars following their paper chromatographic separation on ion exchange papers. These procedures may be used to quantitate all of those components in 5 $\mu$l of a mixture which are present in amounts ranging from 0.1 to 10,000 nmoles. The quantitation gives approximately 10% accuracy at the lower end of the sensitivity range. (auth)

**22821** APPLICATION OF PERTURBED ANGULAR CORRELATION STUDIES TO BIOLOGICAL PROBLEMS. Meares, C. F. Stanford, CA; Stanford Univ. (1972). 249p. University Microfilms Order No. 73-4557.

Thesis (Ph.D.).

The sensitivity and in vivo applicability inherent in $\gamma$ counting experiments make PAC (perturbed angular correlation) a potentially useful technique for rotational labeling studies in biological systems. The theory for perturbed angular correlations was extended to include the possibility of adiabatic variation in the interaction Hamiltonian for the intermediate state. The use of PAC for investigation of the motion of radioactive species in viscous media or bound to macromolecules is discussed. The perturbed angular correlation for the $\gamma$ cascade from a nucleus rigidly bound to a molecule of arbitrary shape in solution has been calculated using a diffusion model for rotational reorientation. In addition, the case of a tracer nucleus bound through a single flexible link in a spherical molecule is examined. The conclusions of practical significance are that the perturbation factor depends only weakly on the shape of the molecule, but even relatively slow internal rotation at the site of attachment of the tracer can markedly affect the experimental result. Experiments provide a good evidence that the perturbed angular correlation reflects the effective molecular rotational correlation time at the metal binding site, and that $^{111m}$Cd can be used as a rotational tracer to label biological macromolecules. A binding site for radioactive indium ions on the enzyme ribonuclease was produced by selective reduction of a single disulfide bond on the enzyme. The 173-247 keV $\gamma$ cascade following the electron-capture decay of $^{111}$In shows a markedly perturbed angular correlation when the nucleus is bound at this site. The denaturation of the labeled enzyme by guanidine at pH 5.5 was observed by means of PAC, and the results are compared with previous work. The average association constant between the antibody and the labeled chelate was determined from PAC measurements, and this value agrees well with the results of equilibrium dialysis. These experiments demonstrate that information concerning macromolecular behavior can be obtained from PAC experiments using chemically specific labels. It has been shown that the chemical stability of several labeled compounds after injection into live mice can be studied by means of PAC. The binding of radioactive ions to macromolecules in vivo is readily detected by a simple external counting procedure. (Diss. Abstr. Int., B) (MCG)

**22822** MEDICAL APPLICATION OF SHORT-LIVED RADIONUCLIDES. Boyd, R. E.; Lane, E. A. (Australian Atomic Energy Commission, Lucas Heights). At. Energy Aust.; 16: No. 1, 2-10 (Jan 1973).

Uses of short-lived radioisotopes, in particular $^{99m}$Tc, are reviewed with particular reference to diagnostic techniques and radiopharmaceuticals. Australian distribution of radiopharmaceuticals from Lucas Heights is described. (Australia)

# MATERIALS

## Ceramics and Cermets

*Refer also to abstracts 22280, 22328, 22359, 22856, 22975, and 22997.*

**22823** (AD-865321) RESEARCH AND DEVELOPMENT OF REFRACTORY OXIDATION-RESISTANT DIBORIDES. PART II. Volume V. Thermal, Physical, Electrical, and Optical Properties. Technical Report, 15 September 1967–15 May 1969. Clougherty, E. V.; Wilkes, K. E.; Tye, R. P. (Manlabs, Inc., Cambridge, Mass.). Nov 1969. Contract AF33(615)-3671. 93p. (AFML-TR-68-190(Pt.2)(Vol.5)). NTIS.

Thermal conductivity data were measured from 100 to 1000°C and were calculated from thermal diffusivity, specific heat, and density data from 1000 to 2000°C for compositional and microstructural variations of $ZrB_2$ and $HfB_2$ with SiC and/or C additives varying in total content from 20 to 34 vol %. The specific heat data were obtained from drop-calorimetry methods for selected compositions and by calculations from constituent values for other compositions. Linear expansion data were obtained from room temperature to 2000°C by direct-view and differential dilatometry for compositions of $ZrB_2$ with SiC and/or C additives. Electrical resistivity data were obtained from room temperature to 1000°C; all compositions displayed positive temperature coefficients. Total normal emittance data were measured from 1600 to 2300°C for unoxidized diboride compositions. (auth)

**22824** (AD-865809) RESEARCH AND DEVELOPMENT OF REFRACTORY OXIDATION-RESISTANT DIBORIDES. PART II. Volume IV. Mechanical Properties. Technical Report, 15 September 1967–15 May 1969. Rhodes, W. H.; Clougherty, E. V.; Kalish, D. (Manlabs, Inc., Cambridge, Mass.). Jan 1970. Contract AF33(615)-3671. 153p. (AFML-TR-68-190(Pt.2)(Vol.4)). NTIS.

Hot-pressed diboride compositions of $ZrB_2$ or $HfB_2$ with additions of SiC and/or C were employed to produce materials with a range of compositions and microstructural variations of porosity and grain size for mechanical-property evaluations which included bend strength and elastic modulus from room temperature to 1800 and 2100°C, respectively; deformation characteristics from 1800 to 2200°C, short-time compressive creep from 1000 to 1800°C, and a limited stress-rupture time data at 1040°C. All data except the stress-rupture tests were obtained from measurements in either vacuum or inert atmosphere; the stress-rupture tests were conducted in air. (auth)

**22825** (AD-866558) RESEARCH AND DEVELOPMENT OF REFRACTORY OXIDATION-RESISTANT DIBORIDES. PART II. Volume II. Processing and Characterization. Technical Report, 15 September 1967–15 May 1969. Clougherty, E. V.; Hill, R. J.; Rhodes, W. H.; Peters, E. T. (Manlabs, Inc., Cambridge, Mass.). Jan 1970. Contract AF33(615)-3671. 198p. (AFML-TR-68-190 (Pt.2)(Vol.2)). NTIS.

The investigation was undertaken to prepare a number of diboride materials containing either $ZrB_2$ or $HfB_2$ as the principal component with selected additives designed to enhance one or more of the following: oxidation resistance, mechanical properties, and thermal stress resistance. Diboride materials, including $ZrB_2$ and $HfB_2$ with no additive, were fabricated with microstructural variations of grain size and porosity, principally by conventional hot-pressing procedures suitable for the production of components such as nose caps, leading edges, vanes, and similar objects anticipated for use in high-velocity flight or reentry conditions. (auth)

**22826** (AD-873010) RESEARCH AND DEVELOPMENT OF REFRACTORY OXIDATION-RESISTANT DIBORIDES. Part II. Volume VII. Application Evaluations and Design Considerations. Technical Documentary Report, 15 September 1967–15 November 1969. Clougherty, E. V.; Anthony, F. M. (Manlabs, Inc., Cambridge, Mass.). May 1970. Contract AF33(615)-3671. 143p. (AFML TR-68-190(Pt.2)Vol.7)). NTIS.

Results of material-centered (cold gas/hot wall) and environment-centered (hot gas/cold wall) tests obtained for hot-pressed diboride materials fabricated principally from $ZrB_2$ or $HfB_2$ with additions of SiC and carbon are presented to demonstrate diboride material attributes for use as: (1) nose caps and leading edges of hypersonic high L/D glide reentry vehicles, (2) air inlet leading edges and related components of advanced air augmented propulsion systems for hypersonic vehicles, and (3) nozzles and related hardware for rocket motors. (auth)

**22827** (AD-873257) RESEARCH AND DEVELOPMENT OF REFRACTORY OXIDATION-RESISTANT DIBORIDES. Part II. Volume I. Summary. Technical Documentary Report, 15 September 1967–15 November 1969. Clougherty, E. V. Manlabs, Inc., Cambridge, Mass.). Jun 1970. Contract AF33(615)-3671. 104p. (AFML-TR-68-190(Pt.2)(Vol.1)). NTIS.

A system of ceramic additives, principally SiC and/or C, were employed with $ZrB_2$ and $HfB_2$ to produce compositions which could be hot pressed to full density with fine grain sizes of 2 to 10 $\mu$. Compositional variations of SiC and C produced materials of varying oxidation resistance, mechanical properties, and thermal stress resistance. The chief effect of the addition of SiC is an improvement in oxidation resistance; the addition of C, a decrease in the bulk elastic modulus and the development of crack arresting characteristics. (auth)

**22828** (AECL-4353) MATERIALS RESEARCH IN ATOMIC ENERGY OF CANADA LIMITED. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Fall 1972. 26p. Dep. NTIS (U. S. Sales Only). AECL $1.00.

Research progress is described in six sections in the report. A separate abstract was prepared for each of four sections. Sections for which no abstracts were prepared are concerned with crystal defects and transport in anodic oxides. (JRD)

*For abstracts of individual sections see: 22829–22832.*

**22829** (AECL-4353, pp 2-6) FABRICATION OF COATED PARTICLE FUEL. Rondeau, R. K.; Lee, H. R. (Whiteshell Nuclear Research Establishment, Pinawa, Manitoba). Fall 1972.

Three-stage processes for fabrication of fuel particles dispersed in graphite are described. Information is included on microsphere fabrication, coating processes, and pellet fabrication. (JRD)

**22830** (AECL-4353, pp 7-12) STRESS-CORROSION CRACKING OF ZIRCONIUM ALLOYS. Cox, B. (Chalk River Nuclear Labs., Ont.). Fall 1972.

The effects of environment on stress-corrosion cracking of Zr alloys are reviewed. Information on Zr-alloy cracking in various environments at a number of different temperatures is presented in tabular form. (JRD)

**22831** (AECL-4353, pp 13-15) STRESS-CORROSION CRACKING OF ZIRCONIUM ALLOY FUEL ELEMENT SHEATHS IN IODINE VAPOR. Wood, J. C. (Chalk River Nuclear Labs., Ont.). Fall 1972.

Metallurgical factors affecting stress-corrosion cracking of Zr alloys in $I_2$ vapor are described. Discussions are included on cracking mechanisms associated with fuel cladding. (JRD)

**22832** (AECL-4353, pp 16-18) DISTRIBUTION OF ZIRCONIUM HYDRIDE IN ZIRCALOY. Ambler, J. F. R. (Chalk River Nuclear Labs., Ont.). Fall 1972.

Results of investigations show that in slowly cooled Zircaloy the amount of intergranular hydride is a linear function of the hydrogen concentration. Below approximately 423°K all the hydride is precipitated at the grain boundaries. The orientation frequency of the intragranular hydride is a non-linear function of the hydrogen concentration. (auth)

**22833** (ANL-7975) CHEMICAL ENGINEERING DIVISION REACTOR SAFETY AND PHYSICAL PROPERTY STUDIES SEMI-ANNUAL REPORT, JULY–DECEMBER 1972. Chasanov, M. G.; Fischer, J.; Fredrickson, D. R.; Gabelnick, S. D.; Leibowitz, L.; Ross, L. E.; Levenson, M.; Vogel, R. C. (Argonne National Lab., Ill.). Jan 1973. Contract W-31-109-Eng-38. 20p. Dep. NTIS $4.00.

Results of reactor safety and physical properties studies are presented. Measurement of the enthalpy of $U_3Si$ from 600 to 1200°K is reported along with matrix-isolation studies of infrared spectra of UO, PrO, and $PrO_2$, and density data for molten basalt to 1700°C. Information is included on development of equipment to measure the thermal diffusivity of molten $UO_2$. This data is being obtained for use in determining the viscosity and density of molten solutions of $UO_2$ in basalt. Progress in measurements on enthalpies of molten mixed oxides is summarized. (auth)

**22834** (ANL-Trans-935) CONCERNING THE OCCURRENCE OF MIXED NEPTUNIUM OXIDES. Translation by Gerda Siegel (Argonne National Lab., Ill.), of NIIAR-P-138 1972. 22p. Dep. NTIS.

Methods for the production of mixed neptunium oxides were verified. It was established that the decomposition of Np(V), Np(VI) hydroxides and of ammonium neptunate in an atmosphere of $NO_2$ at 300 to 400°C occurs with the formation of neptunium pentoxide $Np_2O_5$. The determination of the chemical composition of the resulting oxides was carried out by spectrophotometric titration of solutions of these oxides in $HClO_4$. X-ray-diffraction patterns showed that the crystal lattice of $Np_2O_5$ has an orthorhombic cell with weak monoclinic distortion; the parameters of the lattice coincide with the parameters of the mixed oxide phase described earlier. According to the results obtained it is impossible, at the present time, to take the existence of mixed neptunium oxides for granted. (auth)

**22835** (BMBW-FBK-72-30) POST-IRRADIATION EXAMINATIONS OF THE BOILING-SUPERHEAT FUEL BUNDLE H 5. Schoenfeld, H. (Bundesministerium Fuer Bildung und Wissenschaft, Bonn (West Germany)). Dec 1972. 74p. (In German). Dep. NTIS (U. S. Sales Only).

Results of post-irradiation examinations of the superheat-fuel bundle H5 showed that it is possible to reduce the eccentricity of the inner tube by using $UO_2$ centering pellets and thus to improve the irradiation behavior of the HDR fuel elements. The cladding materials (outer tube: stainless steel No. 1.4981, inner tube: Inconel 625) revealed an excellent corrosion resistance in boiling water or superheated steam, respectively. Small interactions between the fuel and the inner tube, probably due to fission products, are considered as uncritical with regard to the cladding integrity. (auth)

**22836** (CEA-CONF-2133) RF AND DC REACTIVE SPUTTERING FOR CRYSTALLINE AND AMORPHOUS $VO_2$ THIN-FILM DEPOSITION. Duchene, J.; Terraillon, M.; Pailly, M. (Commissariat A L'Energie Atomique, Grenoble (France). Centre D'Etudes Nucleaires). 21 Sep 1972. 11p. (Conf-720568-2). Dep. NTIS (U. S. Sales Only).

From International conference on thin films; Venice, Italy (15 May 1972).

Experimental conditions for depositing crystalline and amorphous $VO_2$ thin films by rf and dc sputtering are given. Substrate temperature and ion energy are the key parameters to obtain $VO_2$ crystalline deposits at a given oxygen partial pressure. This crystalline $VO_2$ undergoes a semiconductor-to-metal phase transition at 68°C with a resistivity change as high as $10^3$. The associated hysteresis effect is about 5°C at the transition. The $VO_2$ films with a transition show an increase in resistivity with thickness; amorphous ones are more resistive without any electrical discontinuity. When the crystalline oxide film is coated with another deposit under given thermal deposition conditions, the resistivity jump at 68°C is decreased with a spreading of the hysteresis width. In some cases, the transition becomes quite negligible. This may be due to a mechanical strain brought about by the superimposed film and dependent on the deposition temperature. Finally, some $VO_2$-film device applications based on the resistivity change (switching) and on the optical index variation at the transition (display) are presented. (auth)

**22837** (CONF-720931-4) INVESTIGATION OF THE TRANSPLUTONIUM OXIDES BY X-RAY AND ELECTRON DIFFRACTION. Baybarz, R. D.; Haire, R. G. (Oak Ridge National Lab., Tenn.). 1972. 22p. Dep. NTIS.

From Symposium on the chemistry of the transuranium elements; Moscow, USSR (4 Sep 1972).

Results of research are presented and discussed concerning tetravalent Cf, preparation of $CfO_2$, preparation of $Es_2O_3$, analysis of $Es_2O_3$ by electron diffraction, preparation of monoclinic $Bk_2O_3$, and preparation of hexagonal $Cm_2O_3$, $Bk_2O_3$, and $Cf_2O_3$. Data on the melting points of these oxides are included along with phase diagrams for a number of actinide sesquioxides. (JRD)

**22838** (GEAP-12338) FISSION GAS RE-SOLUTION RATES. Quarterly Report 8, April 1, 1972—June 30, 1972. Marlowe, M. O. (General Electric Co., Pleasanton, Calif. Vallecitos Nuclear Center). Aug 1972. Contract AT(04-3)-189. 24p. Dep. NTIS.

Progress in an experimental program to determine the resolution rates of fission gases in oxide nuclear fuels under irradiation is described. The fission-gas bubble-size distributions obtained on the second set of irradiated $UO_2$ specimens annealed at 1600°C for 1 hour were characterized and compared with previous results. A specimen holder for re-irradiation of previously irradiated $UO_2$ specimens for partial re-solution of the fission gas bubbles was designed and fabrication is in progress. (auth)

**22839** (GEAP-12361) FISSION GAS RE-SOLUTION RATES. Quarterly Report 9, July 1, 1972–September 30, 1972. Marlowe, M. O. (General Electric Co., Pleasanton, Calif. Vallecitos Nuclear Center). Nov 1972. Contract AT(04-3)-189. 5p. Dep. NTIS.

Progress in an experimental program to determine the resolution rates of fission gases in oxide nuclear fuels under irradiation is described. Three $UO_2$ specimens previously irradiated and post-irradiation annealed were re-irradiated in the NTR. Microstructural characterization of archive unirradiated $UO_2$ specimens was initiated. (auth)

**22840** (HEDL-SA-339) POROSITY MEASUREMENT IN NUCLEAR FUEL BY IMAGE ANALYSIS. Treibs, H. A. (Hanford Engineering Development Lab., Richland, Wash.). 19 May 1972. Contract AT(45-1)-2170. 12p. (CONF-720671-1). Dep. NTIS.

From 19th international symposium on electron microscopy; Chicago, Illinois, USA (26 Jun 1972).

Techniques used to characterize the pore size distribution of unirradiated mixed $UO_2-PuO_2$ fuel pellets are described. The measurements from which the pore size distributions are estimated are made on plane sections of the specimens. Information is included on photography, measurements, and computation. (JRD)

**22841** (HEDL-TME-72-140) EVALUATION OF MIXED U, Pu OXIDE SINTERING VARIABLES AND $PuO_2$ POWDER SOURCE. Final Report. Barr, M. J. (Hanford Engineering Development Lab., Richland, Wash.). Jan 1971. Contract AT(45-1)-2170. 56p. Dep. NTIS $5.45.

Effects of variations in $PuO_2$ particulate characteristics, percent $PuO_2$ addition, pressing pressure, and sintering variables on $UO_2-PuO_2$ sintered pellet density and microstructure were evaluated. Results were statistically evaluated and model equations for green pellet density, sintered pellet density, and variation of sintered pellet density and diameter within groups were obtained. Values of multiple correlation coefficients indicate that approximately 99.7 percent of the green pellet density variation and 91.7 percent of the sintered pellet density variation can be explained by the model equations. Sintered pellet microstructures are presented and discussed according to accepted solid state sintering theory. The micrographs presented demonstrate the variations in solid solution grain growth and porosity occurring during the intermediate and final stages of sintering. (auth)

**22842** (LBL-1177) MASS-SPECTROMETRIC INVESTIGATION OF LASER-INDUCED VAPORIZATION OF BINARY SOLID COMPOUNDS. Olstad, R. A. (California Univ., Berkeley. Lawrence Berkeley Lab.). Dec 1972. Contract W-7405-eng-48. 198p. Dep. NTIS $12.00

Thesis.

The laser-induced vaporization of iron and of a binary solid compound, zirconium hydride, was studied using a quadrupole mass spectrometer. A Q-switch ruby laser with pulse width of 80 ns was used to heat zirconium hydride samples under high vacuum to temperatures up to 2500°C. The mass spectrometer ionizer was located in a line-of-sight path 40 cm from the target. By an analysis of the measured mass-spectrometer signals, the rate of vaporization of hydrogen during the rapid temperature transient could be determined. Application of an equilibrium model to the vaporization process predicts that predominantly $H_2$ (rather than H atoms) should be emitted. The vaporized $H_2$ should have a Maxwellian velocity distribution characteristic of the instantaneous surface temperature, and the rate of vaporization should be related to the $H_2$ vapor pressure by the Langmuir equation. Since the $H_2$ vapor pressure is a function of both surface temperature and surface hydrogen concentration, it was necessary to solve simultaneously the time-dependent heat conduction and hydrogen diffusion equations in the heated zirconium hydride in order to predict the vaporization rates. It was found that H atom and $H_2$ molecules were emitted at thermal equilibrium with the surface. At low laser power density, the magnitude of the $H_2$ signals agreed with the equilibrium model. At high laser power density, the magnitude of the $H_2$ signals was less than predicted, possibly because of a diffusion barrier at the surface. The H atom signals were much larger than predicted, indicating that they were produced by a nonequilibrium surface process. Conventional mode laser pulses (1 msec duration) were used to vaporize iron samples. The measured mass spectrometer signals were in agreement with equilibrium calculations if the flow of molten iron was taken into account. (auth)

**22843** (RFP-1911) SURFACE FILM THICKNESS DETERMINATION BY REFLECTIVITY MEASUREMENTS. Larson, D. T.; Lott, L. A.; Cash, D. L. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). 1972. Contract AT(29-1)-1106. 19p. (CONF-721067-2). Dep. NTIS.

From Annual meeting of Optical Society of America; San Francisco, California, USA (17 Oct 1972).

The thicknesses of $UO_2$ films from 100 to 1800 Å on uranium substrates were determined from reflectivity measurements in the visible region. The reflectivity measurements on the U/$UO_2$ system were analyzed by two different methods to determine film thicknesses. In the first method, film thicknesses were determined by comparing theoretical reflectivity calculations with the experimental reflectivity measurements. In the second method, film thicknesses were determined by obtaining the best match of the colorimetric properties (wavelength, excitation purity, and luminous reflectance) of the sample with the colorimetric properties of a predetermined film thickness calibration curve. (auth)

**22844** (SLA-73-57) VAPOR COMPOSITION AND CHEMICAL REACTIONS OF CARBON ATOMS AND MOLECULES FROM GRAPHITE AND FROM TANTALUM CARBIDE HEATED BY LASER RADIATION. Meyer, R. T.; Lynch, A. W.; Freese, J. M. (Sandia Labs., Albuquerque, N. Mex.). Feb 1973. 43p. Dep. NTIS $4.25.

The vapor composition above graphite and above tantalum carbide together with the chemical reactions of $C_1$, $C_2$, and $C_3$ were studied by the techniques of pulsed laser heating, time-resolved mass spectrometry, and gas-phase titrations. The relative abundances for the vaporized species $C_1$, $C_2$, and $C_3$ were 1.0 : 1.4 : 17 for graphite and 1.0 : 0.059 : 2.2 for tantalum carbide. The different relative abundances of vaporized $C_n$ species from graphite and from tantalum carbide were selected to provide an identification of some of the specific gas phase reactions with $O_2$, $H_2$, and $CH_4$. The $C_n$ species reacted quantitatively with $O_2$ in the gas phase to form CO and $CO_2$; $CO_2$ was the product of the reactions of $C_2$ and/or $C_3$. The $O_2$ titration procedure allowed a determination of the relative amount of mass loss as vapor and as particulate matter. $C_2H_2$ was the major product of $C_n$ reactions with $H_2$ and accounted for 85 to 90 percent of the mass loss from graphite. $CH_4$, $C_4H_2$, and mass 78 were minor products. A low pressure plateau at ~0.5 torr in the $H_2$ titration curve was attributed to the completion of the reaction of $C_2$ via a two step mechanism: (i) $C_2 + H_2 \rightarrow C_2H + H$; (ii) $C_2H + H_2 \rightarrow C_2H_2 + H$. $C_3$ reacted with $H_2$ at pressures from ~0.5 to 10 torr to form the major quantity of $C_2H_2$, but the mechanism was not elucidated. The overall reaction probability of laser vaporized carbon species (predominately $C_3$) was greater with $O_2$ than with $H_2$. The reaction of $C_n$ species with $CH_4$ was complicated by the pyrolysis of the $CH_4$ on the laser heated substrate; $C_2H_2$ and $H_2$ were the principal products of both the vapor phase reactions and the pyrolysis. The techniques and results evolved provide a foundation for evolving the elementary reactions of carbon atoms and molecules and for determining the vapor compositions of graphites and carbides at very high temperatures. (auth)

**22845** NUCLEAR FUEL. Triggiani, L. V.; Haberman, N.; Sanchez, M. G. (to W. R. Grace and Co.). U.S. Patent 3,708,432. 2 Jan 1973. Filed date 28 Aug 1969. 6p.

A process is described for preparing a nuclear fuel containing small amounts of inorganic ions by impregnating formed particles with inorganic salts. (Official Gazette)

**22846** IMPROVEMENTS IN OR RELATING TO FURNACES. Spooner, J. A.; James, R. H. (to United Kingdom Atomic Energy Authority). English Patent 1,295,664. 8 Nov 1972. Filed date 19 Mar 1969. 8p.

Reference is made to furnaces for gas–solid reactions. Disadvantages of conventional boat-train furnaces are described. The furnace described comprises a number of abutting moveable crucibles, with apertured ends, forming a closed duct. The crucibles are interfitting and extend between and through two spaced apertured guides. The arrangement is such that the open end of each crucible is in interfitting relation with the base of an adjoining crucible. The crucibles are introduced through the first guide means and moved into and through the second guide means. Heating is accomplished between the guide means by conduits heated electrically and having heat insulating jackets. The gas moves through the duct in a direction opposite to that of the crucibles. Examples given include reactions of uranium nitrides and carbides. (UK)

**22847** MODULATED MOLECULAR BEAM STUDY OF THE ENERGY OF SIMPLE GASES SCATTERED FROM PYROLYTIC GRAPHITE. Siekhaus, W. J.; Schwarz, J. A.; Olander, D. R. (Univ. of California, Berkeley). Surface Sci.; 33: No. 3, 445-460 (Dec 1972).

The energy of rare gases and several diatomic gases after scattering from pyrolytic graphite was determined by molecular beam-phase sensitive detection methods. The angle of incidence of the molecular beam and the angle of sampling of the reflected molecules were both fixed at 45°. The phase shifts induced by changing either the temperature of the incident gas or the solid were utilized to determine an apparent temperature of the scattered molecules. Results showed that the apparent temperature of the reflected molecules was independent of the temperature of the incident gas. With increasing solid temperature, the reflected gas temperature increased up to a limiting value which was dependent on the gas and the surface only. Both the basal and prismatic faces of graphite were investigated. In addition, a prism plane specimen which had not been subjected to high-temperature heat treatment was studied. The apparent temperature of the reflected beam did not depend upon the crystallographic face of the graphite but was markedly reduced by high-temperature annealing. (auth)

**22848** CRYSTAL STRUCTURE OF NIOBIUM HYDRIDE. Rashid, M. S.; Scott, T. E. (Ames Lab., Iowa). J. Less-Common Metals; 30: No. 3, 399-403(1973).

Results of studies on the composition, crystal structure, and lattice parameters of near-stoichiometric niobium monohydride are presented. X-ray data on the Nb–H system is given in tables. (JRD)

**22849** TRANSFORMATIONS IN hcp ZIRCONIUM–OXYGEN ALLOYS. Claisse, F.; Tran Minh Giam (Univ. Laval, Quebec). J. Less-Common Metals; 30: No. 3, 377-385(1973).

Electrical resistivity measurements were made on hcp zirconium containing 12 to 29 at. % oxygen in solid solution. Two different transformations were observed on heating and cooling. One transformation is $10^4$ times more rapid than the other but both transformations have an activation energy compatible with mechanisms based on oxygen diffusion. The slower transformation is attributed to oxygen ordering and the faster is attributed to oxygen segregation in crystal defects, for example, stacking faults. The critical temperatures of the transformations were determined. (auth)

**22850** PRESENCE OF COHERENT PRECIPITATE IN $VC_{0.76}$ MONOCRYSTALS. Thornton, P. H. (Ford Motor Co., Dearborn, MI); Govila, R. K. J. Less-Common Metals; 30: No. 3, 343-349 (1973).

An electron-transmission-microscope study in $VC_{0.76}$ monocrystals revealed the presence of a fine, coherent, ordered precipitate randomly distributed in a disordered matrix. The precipitate revealed a domain structure similar to that observed within the domains in $VC_{0.84}$ monocrystals. The VC phase field therefore exhibits, at temperatures low relative to $T_m$, a two-phase region of co-existing ordered and disordered components, in addition to the previously reported $VC_{0.84}$ and $VC_{0.88}$ superlattices. (auth)

**22851** SCALE FORMATION AND BEHAVIOR OF SOME HIGH-TEMPERATURE REFRACTORY BORIDES IN VACUUM. Glebov, L. O.; Lavrenko, V. O.; Kiryakova, I. E. (Inst. of Problems in Material Studies, Kiev). Dopov. Akad. Nauk Ukr. RSR, Ser. B; No. 11, 1014-1017(Nov 1972). (In Ukrainian).

By vacuum microweighing, petrographic, and X-ray analyses, the process of scale formation of chromium, zirconium, and tungsten borides was studied in pure oxygen at a temperature of 1473°K and pressure of 740 torr. The borides ($CrB_2$, $ZrB_2$, and $W_2B_5$) behavior at different temperatures in vacuum was tested. Under these conditions, zirconium boride was found to be the most corrosion-resistant. Chromium boride is the most resistant material in vacuum. (auth)

**22852** THORIUM HYDRIDES. Zaborenko, K. B.; Os'kina, T. E. Vestn. Mosk. Univ., Ser. II. Khim.; 13: No. 5, 535-537(1972). (In Russian).

The decomposition of thorium hydrides in argon flow was investigated under linear temperature increase. The methods used were differential thermal, emanation, and that of simultaneous analysis for hydrogen. Based on the data on emanation ability, the changes of specific surface in hydride decomposition were estimated. (auth)

**22853** MANUFACTURE AND PROPERTIES OF POWDER-METALLURGICAL REFRACTORY-COMPOUND FIBERS AND POROUS-FIBER MATERIALS. Samsonov, G. V.; Matsera, V. E. (Inst. of Materials Science, Kiev). Sov. Powder Met. Metal Ceram. (Engl. Transl.); 11: No. 9, 719-723(Sep 1972).

Translated from Porosh. Met., Akad. Nauk Ukr. SSR; 11: No. 9, 42-47(Sep 1972).

Using titanium carbide and titanium and zirconium diborides as typical examples, a study was made of the extrusion of fibers from plasticized powder mixtures. The optimum mixture compositions and extrusion conditions, ensuring stability of filament discharge, were determined. Certain characteristic features of the sintering behavior of refractory compound fibers were discovered. Conditions securing maximum possible strength in sintered refractory fibers were determined. Ways of further increasing their strength are discussed. Porous materials were produced from sintered fibers. It is shown that the hydraulic properties of fiber filters approach those of filters from wire fibers. Fiber filters are comparable in strength to porous materials from powders and can be expected to surpass them in stopping power. (auth)

**22854** EFFECT OF HIGH-TEMPERATURE ANNEALING ON RUPTURE CHARACTERISTICS OF ZIRCONIUM CARBIDE. Travushkin, G. G.; Bukatov, V. G. (All Union Scientific-Research Inst. of Refractory Metals and Hard Alloys, Moscow). Sov.

Powder Met. Metal Ceram. (Engl. Transl.); 11: No. 9, 735-736(Sep 1972).

Translated from Porosh. Met., Akad. Nauk Ukr. SSR; 11: No. 9, 63-64(Sep 1972).

Results of tests of sintered and annealed samples of ZrC are described in which microhardness, rupture energy, and transverse rupture strength were measured. Rupture diagrams were also constructed. (JRD)

**22855** ELECTROMAGNETIC QUALITY CONTROL OF METALLOCERAMIC ALLOYS. Battalov, Sh. G.; Kuklin, L. G.; Pravdin, L. S.; Sandovskii, V. A.; Syrochkin, V. P. (Inst. of Metal Physics, Sverdlovsk, USSR). Defektoskopiya; No. 5, 5-13(1972). (In Russian).

The possibility of using an electromagnetic method as a nondestructive testing procedure on VK15 type cermets (Co–WC) was investigated. The effect of microstructure of the solid alloy on some magnetic characteristics in constant magnetic fields was determined. The effect of microstructure on the amplitude and phase of the emf in eddy current and transfer converters was studied. Controlled parameters in these tests were the average grain size of the carbide phase, the presence of pores, and the free graphite or $\eta_1$-phase. (KSW)

**22856** LONG-TERM OXIDATION OF SUPERALLOYS. Angerman, C. L. (Savannah River Lab., Aiken, SC). Oxidation Metals; 5: No. 2, 149-167(Nov 1972).

The oxidation of 24 commercially available superalloys was measured after exposure in still air at up to 1150°C for up to 10,000 h. The total depth affected by oxidation, which includes subscale reactions, followed the expected exponential relationship with temperature and the expected parabolic relationship with exposure time at 1000°C; oxidation of Haynes 25 and TD nickel chromium was not parabolic at 1150°C. The alloys could be divided into four groups according to relative resistance to oxidation at 1000°C. These differences in resistance could be explained qualitatively by the nominal compositions of the alloys. (auth)

**22857** AUTOMATIC FLUOROSCOPY OF URANIUM BALLS. Metal Progr.; 103: No. 3, 72-73(Mar 1973).

A diagrammatic description is presented of an x-ray diagnostic system capable of evaluating 350 carbon-coated fuel spheres per hour for defective sphere detection. (JRD)

**22858** EQUILIBRIUM STUDIES OF THE REACTION OF ALUMINUM CHLORIDE WITH RARE-EARTH OXIDES. Part II. $Nd_2O_3$ and $Sm_2O_3$. Atchayya, M.; Dadape, V. V. (National Chemical Lab., Poona, India). High Temp. Sci.; 5: No. 1, 1-4(Feb 1973).

The transpiration method was employed to study the following reactions in the temperature range 485 to 745°K: $Nd_2O_3(c) + 0.5\ Al_2Cl_6(g) = 2\ NdOCl(c) + AlOCl(g)$ (1) $Sm_2O_3(c) + 0.5\ Al_2Cl_6(g) = 2\ SmQCl(c) + AlOCl(g)$. (2) The thermodynamic parameters calculated for the reactions are: (1) $\Delta H^\circ_{r298} = 8.7 \pm 0.3$ kcal, $\Delta S_{r635} = 4.1 \pm 0.4$ cal deg$^{-1}$ mole$^{-1}$, $\Delta H^\circ_{f298}$NdOCl(c) = $-247.1 \pm 0.3$ kcal mole$^{-1}$. (2) $\Delta H^\circ_{r298} = 9.6 \pm 0.7$ kcal, $\Delta S_{r560} = 9.3 \pm 1.2$ cal deg$^{-1}$ mole$^{-1}$, $\Delta H^\circ_{f298}$SmOCl(c) = $-247.4 \pm 0.7$ kcal mole$^{-1}$. (auth)

**22859** SUPERLATTICE FORMATION IN Nb–H SOLID SOLUTIONS. Langeberg, J. C.; McLellan, R. B. (Rice Univ., Houston, TX). Scr. Met.; 7: No. 3, 301-304(Mar 1973).

A correlation is made between the thermodynamic properties of the Group V–H bcc ($\alpha$) solid-solution phase with the ordering phenomenon. The tendency to ordering can be explained by the elastic distortion of the tetrahedral sites surrounding a H atom, rendering them unsuitable for occupancy by other H atoms. The partial molar positional entropy in the blocking model is consistent with the experimental variation with composition, and several conclusions from the model are made for the superlattice formation in Nb–H. (DLC)

**22860** FABRICATION OF BONDED-PARTICLE NUCLEAR FUEL STICKS. Davis, F. C.; Cannon, D. D.; Furman, F. J. Jr.; Sease, J. D. (to United States Atomic Energy Commission). U. S. Patent 3,714,305. 30 Jan 1973. Filed date 10 Mar 1971. 6p.

Fuel particles are vibratorily loaded into a given mold volume having a length and cross section corresponding to the final fuel stick dimensions. This compacted body of particles is moved past a bonding mixture injection zone through the coordinated movement of upper and lower rams, together with an internally applied pulsating pneumatic pressure to prevent further bed compaction, for the gradual impregnation of the particle bed with the bonding mixture. Solidification of the bonding mixture occurs very soon after injection so as to provide strength to the fuel sticks. (Official Gazette)

**22861** CARBONIZATION OF ZIRCONIUM SILICATE WITH PLASMA ARCS. Matsumoto, Osamu; Miyazaki, T. (Aoyama Gakuin Univ., Tokyo). High Temp. Sci.; 5: No. 1, 40-49(Feb 1973).

The carbonization of zirconium silicate by graphite in an argon or argon–hydrogen plasma arc was studied. Metallic cake was formed on the anode, and yellow powder was deposited on a cooling copper coil above the anode. X-ray-diffraction patterns, chemical analysis, infrared absorption spectra, and electron diffraction patterns showed that the cake was ZrC including little impurity and the powder was SiO. In the absence of graphite, $ZrSiO_4$ decomposed to $ZrO_2$ and $SiO_2$ at high temperature in the plasma arc. The overall reaction of ZrC formation by the carbonization of $ZrSiO_4$ appears to $ZrO_2 + SiO_2 + 4C \rightarrow ZrC + SiO + 3CO$. The molar ratio of graphite to $ZrSiO_4$, current, and reaction time considerably affected the reaction. The mixing of hydrogen into the argon plasma increased the reaction rate. Zirconium carbide formed from $ZrSiO_4$ in this study had a nearly stoichiometric composition and its properties were comparable to those of ZrC formed by the carbonization of $ZrO_2$. (auth)

**22862** NONSTOICHIOMETRY OF THE $U_3O_8$ PHASE AT HIGH TEMPERATURE. Dharwadkar, S. R.; Chandrasekharaiah, M. S. (Bhabha Atomic Research Centre, Bombay). High Temp. Sci.; 5: No. 1, 5-7(Feb 1973).

The composition–temperature relation of $U_3O_{8-x}$ was investigated in air at 675 to 1125°K. Above 700°K, $U_3O_{8-x}$ is oxygen-deficient. Simple ignition of urania in air at 1275 or 1125°K is shown to be unsuitable for O/U analysis. Some calculations of oxygen pressures at 1125°K are given. (DLC)

**22863** DETERMINATION OF $UO_2$ POWDER ACTIVITY BY DTA. Pollanz, H. (Kernforschungszentrum, Karlsruhe, Ger.). J. Nucl. Mater.; 46: No. 2, 210-212(Mar 1973).

Calorimetric DTA measurements were made of the powder activity (which characterizes the sinterability) of four $UO_2$ powders. Energy differences $\Delta A$ were calculated from the measured $\Delta T$ areas. $\Delta A$ decreases with increasing presintering time. Total surface energy is plotted versus specific surface. Results show that the energy state of $UO_2$ powders cannot be derived from BET surface measurements alone; their integral activity must also be measured, and relative values can be found by means of DTA. (DLC)

**22864** THERMAL DIFFUSIVITY AND CONDUCTIVITY OF $U_2C_3$ UP TO 2200K. De Coninck, R.; Van Lierde, W.; Gijs, A. (SCK/CEN, Mol, Belgium). J. Nucl. Mater.; 46: No. 2, 213-216(Mar 1973).

The thermal diffusivity and conductivity of $U_2C_3$ were measured between 1000 and 2200°K using a modulated electron-beam apparatus, and at 313.6°K using a Schroeder apparatus. Between room temperature and 2050°K, the thermal conductivity follows the equation $k = (5.05 \times 10^{-2} + 5.63 \times 10^{-5})\ T\ (W \cdot K^{-1} \cdot cm^{-1})$. Above 2050°K, a sudden decrease occurs due to transformation of $U_2C_3$ to UC + $UC_2$. This reaction can be reversed, ending with specimen failure from cracking. (DLC)

**22865** BORON CARBONITRIDE: A HIGH-TEMPERATURE, ELECTRICALLY INSULATING, AND REFRACTORY MATERIAL. Samsonov, G. V.; Eroshenko, A. I.; Ostroverkhov, V. I.; Krat, V. A.; Dubovik, T. V. (Inst. of Problems in Materials Studies, Kiev). Porosh. Met., Akad. Nauk Ukr. SSR; No. 12, 46-48(Dec 1972). (In Russian).

Coarse billets of boron carbonitride were pressed at 1.5 tons/cm$^2$ from a 1:1 mixture of powdered BN and $BC_2$. The electrical resistance, thermal conductivity, thermal expansion, dielectric constant, volatility rate, modulus of elasticity and certain other mechanical properties were measured. (KSW)

**22866** PROTECTIVE SHEATHS FOR THERMOCOUPLES FOR AUTOMATIC HEAT CONTROL OF METALLURGICAL PROCESSES. Kislyi, P. S.; Kuzenkova, M. A.; Struk, L. I.; Morgunovskaya, B. A.; Zvazhenko, V. K.; Bol'shechenko, A. G.; Ostroverkhov, V. I. (Inst. of Problems in Materials Studies, Kiev). Porosh. Met., Akad. Nauk Ukr. SSR; No. 12, 49-56(Dec 1972). (In Russian).

A technique for producing protective sheaths for thermocouples of alloys of zirconium diboride with tungsten is worked out. Some regularities are investigated of pressing sheaths using starch paste and caoutchouc solution in benzine as plasticizer. On the basis of kinetics of sintering and process of formation of structure of zirconium diboride alloys with different contents of tungsten in argon, carbon-containing medium and in-vacuum optimal conditions are chosen for sintering the sheath. Results of sheath tests in melts of synthetic pig iron and steel are presented. (auth)

**22867** BORATING OF CARBIDE COMPONENTS OF SOLID-ALLOYED INSTRUMENT. Kolosvetov, Yu. P.; Navrotskii, B. S.; Zhunskovskii, G. L. (Kiev Polytechnical Inst.). Porosh. Met., Akad. Nauk Ukr. SSR; No. 12, 84-86(Dec 1972). (In Russian).

Interactions of carbides of tungsten and titanium with boron were investigated. Temperature dependence of borating rate and phase composition of interaction products was determined. It was found that, in the process of saturation of hard-alloyed instrument with boron, not only cobalt bond but tungsten carbide as well is borated. (auth)

**22868** INVESTIGATION OF BOROCARBIDES OF RARE-EARTH METALS. Markovskii, L. Ya.; Vekshina, N. V.; Kondrashev, Yu. D. J. Appl. Chem. USSR (Engl. Transl.); 45: No. 6, 1224-1227(Jun 1972).

Translated from Zh. Prikl. Khim.; 45: No. 6, 1183-1187(Jun 1972).

Borocarbides of two types were obtained by heating mixtures of rare-earth metals with boron and carbon at 2000°C. One has the composition corresponding to the formula $LnC_4B_2$. The powder diagrams of these compounds have been obtained, but their structure has not yet been determined. The composition of the other borocarbides corresponds to the formula $LnC_2B_2$. Crystals of $LnC_2B_2$ are shiny black platelets and belong to the hexagonal system. Among the elements studied, only cerium and lanthanum form borocarbides of the first type. Borocarbides of lanthanum, cerium, praseodymium, neodymium, and samarium of the formula $LnC_2B_2$ were obtained in the tetragonal form. The dependence of the composition and structure of borocarbides on the atomic radii of the corresponding rare-earth metals was demonstrated on the basis of experimental results and literature data. (auth)

**22869** PROCESS FOR PRODUCING DENSE PARTICLES OF PLUTONIUM COMPOUNDS USABLE AS FUELS FOR NUCLEAR REACTORS. Cogliati, G.; Recrosio, A.; Lanz, R. (to Comitato Nazionale per l'Energia Nucleare). U. S. Patent 3,709,693. 9 Jan 1973. Priority date 13 Oct 1967, Italy. 6p.

In the process, an acid solution of plutonium(IV) is transformed into a colloidal acid-deficient solution through extraction of nitric acid by means of a liquid anion exchanger until a nitrate-to-plutonium ratio in the range of from 1 to 1.5 is produced and through evaporation of water, if necessary, until a concentration of plutonium in the range of 1 to 2 moles per liter is produced. The colloidal solution of plutonium(IV) may be mixed with a suitable colloidal solution of another metal of the actinide or lanthanide series and/or carbon powder. The resulting colloidal solution is dispersed as drops which are transformed into gel particles calcined at suitable temperatures. (Official Gazette)

**22870** IDENTIFICATION AND ANALYSIS OF EINSTEINIUM SESQUIOXIDE BY ELECTRON DIFFRACTION. Haire, R. G.; Baybarz, R. D. (Oak Ridge National Lab., Tenn.). J. Inorg. Nucl. Chem.; 35: No. 2, 489-496(Feb 1973).

Einsteinium sesquioxide was prepared by calcining submicrogram quantities of the metal nitrate, and the resulting oxide was analyzed by electron diffraction. The lattice parameter of the body-centered cubic $Es_2O_3$ was found to be 10.766 ± 0.006 Å for a hydrogen-reduced oxide sample. The ionic radius of $Es^{3+}$ calculated from this lattice parameter was 0.928 Å, which is approximately midway between the values calculated for $Gd^{3+}$ and $Tb^{3+}$ from their sesquioxides. (auth)

**22871** THERMAL DECOMPOSITION OF $Th_3N_4$ AND $Th_2N_2O$. Kusakabe, T.; Imoti, S. Technol. Rep. Osaka Univ.; 22: 477-488 (Oct 1972).

$Th_3N_4$ and $Th_2N_2O$ were thermally decomposed in the temperature range from 1200 to 1350°C in vacuum. The lattice parameter of ThN in the product varied from 5.180 Å at the early stage to 5.156 Å at the final stage of the decomposition in both cases of $Th_3N_4$ and $Th_2N_2O$. The equilibrium nitrogen pressures for the reactions $2Th_3N_4 = 6ThN + N_2$ and $4Th_2N_2O = 6ThN + 2ThO_2 + N_2$ were determined by heating either $Th_3N_4$ or $Th_2N_2O$ under predetermined nitrogen pressures and by measuring the decomposition temperatures from the change of the specific emissivity of the specimen. The enthalpy and the entropy of formation of ThN and $Th_2N_2O$ were calculated on the basis of these thermodynamic data. (auth)

**22872** DISPLACEMENT THRESHOLDS IN ZnO. Locker, D. R. (Aerospace Research Labs., Wright-Patterson AFB, OH); Meese, J. M. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 237-242(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

Two displacement thresholds have been observed in ZnO single crystals. Above the lower energy threshold of 310 keV, the carrier removal rate increases quadratically with increasing electron beam energy. Above the second threshold at 900 keV, a sharp reduction in the free carrier microwave absorption is observed. Accompanying this, the EPR resonances for several iron group impurities and for the $F^+$ center (ionized oxygen vacancy) become activated and are observable. The color centers which have been associated with F centers are also activated. After a thermal anneal to remove these color centers, irradiation at lower energies yields the same energy dependence for the production of $F^+$ centers as is observed with the electrical measurements as well as the same threshold at 310 keV. The lower threshold at 310 keV is associated with oxygen displacements while the upper threshold at 900 keV is associated with zinc displacements. On the basis of these assignments, a value for the maximum atomic recoil energy of 57 eV is obtained for both zinc and oxygen displacements. (auth)

## Metals and Alloys

### *Corrosion and Erosion*

**22873** (AD-750410) PROPERTIES OF RARE-EARTH METALS AND ALLOYS. Semiannual Technical Report, March 1-July 31, 1972. Douglas, D. L.; Kuenzly, J. D. (California Univ., Los Angeles. School of Engineering and Applied Science). Sep 1972. 20p. (UCLA-ENG-7283). NTIS.

The high-temperature oxidation behavior of $Ni_3Al$ with and without additions of 0.5% yttrium was studied over the range of 900 to 1200°C in air. None of the commonly accepted rate laws were followed by the kinetics. Although the weight gains of samples containing yttrium were consistently 10 to 20% greater than those without yttrium, the steady-state scaling rates were identical. A quantitative x-ray diffraction technique was used to determine the kinetics of growth of the protective alpha-$Al_2O_3$ layer (one of several oxides formed). The alumina growth followed the parabolic rate law under all conditions studied. The presence of yttrium greatly increased the short-time scale adherence. At longer times, however, the outer layer of $NiAl_2O_4$ and unreacted NiO spalled off along with some of the inner $AlO_3$ layer. (auth)

**22874** (AECL-4137) THERMODYNAMICS OF METAL-WATER SYSTEMS AT ELEVATED TEMPERATURES. Part 2. The Iron-Water System. MacDonald, D. D.; Shierman, G. R.; Butler, P. (Atomic Energy of Canada Ltd., Pinawa (Manitoba). Whiteshell Nuclear Research Establishment). Dec 1972. 54p. Dep. NTIS (U. S. Sales Only). AECL $1.50.

Free energies of formation for iron, iron oxides, and ionic species in solution are calculated at elevated temperatures by integrating free energy functions over the range 25 to 300°C. These data are used to derive potential-pH relationships for the iron-water system and to calculate solubilities of iron, magnetite ($Fe_3O_4$) and haematite ($\alpha$-$Fe_2O_3$) as a function of pH at the various temperatures considered. (auth)

**22875** (CONF-721004-3) EFFECTS OF HIGH-TEMPERATURE STEAM EXPOSURE ON THE PROPERTIES OF SUPERHEATER ALLOYS. Cordovi, M. A.; Wilder, A. B.; Rutherford, J. J. B.; Weigel, C. P. (American Society of Mechanical Engineers, New York). [nd]. 40p.

From INCO power conference; Kyoto, Japan (28 Nov 1972).

The performance of established and candidate superheater tube materials when exposed to the action of flowing, high-pressure steam at temperatures higher than those to which they are now generally used in commercial service was investigated. The study was directed toward determination of the resistance of selected ferritic and austenitic alloys to steam corrosion, their metallurgical stability, and the effects of oxide films on their thermal conductivity and heat transfer properties. Discussions are presented on the structural stability of the tube materials as reflected in their mechanical properties, resistance to deformation, and microstructural aspects after exposure for periods up to 36 months to high pressure (2000 psi) steam at temperatures between 1100 and 1500°F. (auth)

**22876** (CONF-730304-1) DUCTILE-BRITTLE BEHAVIOR OF ZIRCALOY FUEL CLADDING. Hobson, D. O. (Oak Ridge National Lab., Tenn.). 1972. 4p. Dep. NTIS.

Results are described of two sets of experiments designed to characterize the ductile-brittle behavior of Zircaloy fuel element cladding in terms of amount of oxidation, degree of penetration of brittle phases into the tube wall, and type of deformation used in the tests. Ring specimens were cut from 0.422-in. OD × 0.027-in.-wall thickness Zircaloy-4 tubes previously steam-oxidized on both inner and outer surfaces at temperatures ranging from 1700 to 2400°F for various times. Two types of deformation tests were employed: high-strain-rate compression (flattening) tests in an argon atmosphere at temperatures from room temperature to 1900°F and slow-strain-rate compression tests from room temperature to 300°F. Test results show that there are correlations between amount of oxidation ($F_w$) and the ductile-brittle, or zero-ductility temperature (ZDT), behavior of Zircaloy-4 fuel-element cladding exposed to steam at various temperatures and subsequently tested in either high- or low-strain-rate compression (flattening). At some steam exposure temperature between 2200 and 2400°F the $F_w$ – ZDT correlation developed from the low-strain-rate tests becomes inapplicable. This is believed to be caused by faster overall diffusion-increased solubility of oxygen in the $\beta$ phase. (auth)

**22877** (CONF-730308-1) CORROSION PRODUCT DEPOSITION IN MOLTEN FLUORIDE SALT SYSTEMS. Koger, J. W. (Oak Ridge National Lab., Tenn.). [nd]. 18p. Dep. NTIS.

From 29th annual National Association of Corrosion Engineers symposium; Anaheim, California, USA (19 Mar 1973).

Hastelloy N (Ni–16%Mo–7%Cr–5%Fe) is compatible with pure fluoride salts and corrosion is difficult to detect. However, when impurities are present, both metal-fluoride and metal corrosion products may deposit as the result of the interaction of molten-fluoride salts and alloys in a temperature-gradient system. Both types of deposits were studied as they have occurred in iron- and nickel-base thermal convection loops operating in the range of 460 to 605°C. In the iron-base loop, metal deposits consisting mainly of iron resulted from extreme changes in the equilibrium constant of the corrosion reaction with changes in temperature and from the highly oxidizing conditions of the salt. Metal–fluoride deposits also caused plugging in both the iron-base and a nickel-base loop and were mainly chromium fluorides. These were precipitated from the saturated salt. Under steady-state (low corrosion rate) conditions, more of the least stable fluoride corrosion products (such as iron and nickel) deposited than the more stable chromium fluorides. The amount of deposition in the cold leg was a function of the overall corrosion rate and varied only a small amount with temperature. Examination of the steady-state deposits with the scanning electron microscope showed several significant features including possible growth steps with cubic symmetry. (auth)

**22878** (ORNL-TM-4069) EFFECT OF OXYGEN ON THE CORROSION OF NIOBIUM AND TANTALUM BY LIQUID LITHIUM. Klueh, R. L. (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 27p. Dep. NTIS $3.50.

The effect of oxygen on the corrosion of niobium and tantalum by liquid lithium at 600°C was studied with static capsules. An increase in the oxygen concentration of the lithium from 100 to 2000 ppM had no measurable effect on the dissolution of either refractory metal, a result that is contrary to the effect of similar oxygen concentrations in sodium and potassium. Exposure to lithium reduced the oxygen content of niobium and tantalum to ≤20 ppM regardless of the oxygen concentration of the lithium. These results agree with thermodynamic calculations that predict that the equilibrium distribution coefficient (i.e., the ratio of the oxygen concentration in the refractory metal to that in lithium) is very much less than unity. When the oxygen concentration of niobium and tantalum exceeded a threshold level, lithium (with no oxygen added) penetrated the refractory metal. Penetration resulted from the formation of a ternary oxide on grain boundaries or preferred crystallographic planes and proceeded by a wedging mechanism, caused by stresses generated by the corrosion product. Penetration was along grain boundaries at low oxygen concentrations, the attack depth and number of affected boundaries increasing with increasing oxygen concentration. At higher oxygen concentrations, transgranular attack also occurred. The threshold oxygen concentrations for attack (grain-boundary penetration) were determined to be 400 and 100 ppM for niobium and tantalum, respectively. (auth)

**22879** (USC–113-p-22-3) EFFECTS OF ELECTRIC AND MAGNETIC FIELDS AND OTHER PHYSICAL PARAMETERS ON THE NUCLEATION, STRUCTURE, AND RESIDUAL PROPERTIES OF VAPOR-DEPOSITED METAL FILMS. Murr, L. E. (University of Southern California, Los Angeles. Electronic Sciences Lab.). Apr 1972. Contract AT(043)-113. 20p. (USCEE–412). Dep. NTIS.

The effects of electric fields on the nucleation and growth of metallic thin films was studied, with particular emphasis on the low-melting point metals. No effects were observed with potential gradients up to 3 kV/cm in the plane of the substrate. Several prominent nucleation characteristics were observed which included vapor–liquid–solid (liquid nuclei supercooling) and vapor–solid nucleation characteristics which were observed to be a function of substrate temperature and film thickness evaporated at $10^{-6}$ torr vacuum. Analyses were made of the effects of substrate temperature, evaporation rate, and film thickness on nucleation, film growth, and continuity. Results indicated the substrate temperature/melting temperature to be a critical factor in film growth, and to influence film continuity as a function of mean foil thickness, in addition to the surface energy of the nuclei, and the energy of the substrate/overgrowth interface. An apparatus was constructed for the application of a magnetic field in the plane of a substrate, having a linear field capability of 0 to 4 kgauss. Films of Ni, Co, and Fe grown under these field conditions showed no effect of a magnetic field in a vacuum of $10^{-6}$ torr. Examinations of Pt overgrowths on Mo, W, and Ir field emitter end form substrates by field-ion microscopy indicated the very early stages of nucleation and film growth to be characterized by an accommodation of the overgrowth specie to the crystallography of the substrate (basal-plane pseudomorphism). Evidence suggests that the overgrowth reverts to its habit crystallography at some critical thickness (usually only about 10 to 20 atom layers), and this relaxation can be accompanied by the introduction of crystal defects. It is concluded that the dominant parameter influencing film growth is the substrate temperature, particularly the substrate temperature/melting temperature ratio. No significant enhancement of grain size in ferromagnetic thin films was observed for field strengths up to 7 kgauss applied perpendicular to the substrate, and up to 4 kgauss applied parallel to the substrate plane. (33 references) (DLC)

**22880** (WARD-3045-T-1-9) CARBON EQUILIBRIUM RELATIONSHIPS FOR AUSTENITIC STAINLESS STEELS IN A SODIUM ENVIRONMENT. Shiels, S. A.; Bagnall, C.; Schrock, S. L. (Westinghouse Electric Corp., Madison, Pa. Advanced Reactors Div.). Feb 1973. Contract AT(11-1)-3045. 29p. AT $4.00.

A technique for measuring the "carburizing potential" of high-temperature sodium was developed. The technique involves exposing Type 304 stainless steel foils in a by-pass chamber at 1300°F. The equilibrium carbon concentration in the foil becomes the measure of carburizing potential. Experimental relationships between the carburizing potential, $C_s$, the carbon equilibrium content of steels exposed to the sodium, $C_e$, and temperature, T, have been developed. The measurement technique, together with the established relationships, can be used to monitor operating systems and predict the consequences of a carbon transient. In addition, the $C_e$ levels in the system can be estimated by assuming a $C_s$ value for LMFBR primary systems. Assuming a $C_e$ value of 50 ppM, it can be stated that, in the case of FTR, there will be no carburizing problems, compensation for decarburization will be required for the upper end of the IHX, the pump and hot leg piping, and the most critical region will be the core structurals where thin walled components will lose a large amount of carbon. The $C_e$ measurements represent only part of the necessary information. Diffusion coefficients for the alloys in question are required for the system temperature range, together with adequate mechanical property data covering the range of carbon and nitrogen levels that have been predicted. (auth)

**22881** ACCURATE ESTIMATION OF THE WORK FUNCTION AND SURFACE ENERGY OF POLYCRYSTALLINE TECHNETIUM. Trasatti, S. (Univ., Milan). Surface Sci.; 32: No. 3, 735-738(Sep 1972).

A rough value of the work function of 4.9 ± 0.1 N is found using Pauling's electronegativity relation. Cartledge's measurement of $9 \times 10^{-5}$ A/cm$^2$ for the exchange current $i_{O,H}$ for electrolytic hydrogen evolution on Tc is combined with $\log i_{O,H} = 6.7\phi - 36.6$ to derive a more exact value of 4.86 ± 0.01 eV for the work function. The heat of adsorption of H is calculated to be ~29 kcal/mol, the metal atom–metal atom bond energy to be 15.1 kcal/mol, the surface tension to be 1920 erg/cm$^2$, and the surface energy to be 45.1 kcal/mol for Tc. (DLC)

**22882** LAMBDA STATE OF NITROGEN ON TUNGSTEN SURFACES. Dawson, P. T.; Peng, Y. K. (McMaster Univ., Hamilton, Ont.). Surface Sci.; 33: No. 3, 565-588(Dec 1972).

The desorption of nitrogen at high coverage from a tungsten surface was studied using ultrahigh-vacuum thermal-desorption mass spectrometry. The high-coverage $\lambda$ states of nitrogen were prepared by activation of nitrogen gas by electron bombardment. Experiments using nonactivated nitrogen gas also showed population of the $\lambda$ states, though with a very small sticking probability of $10^{-7}$. Nevertheless, this result shows that the $\lambda$ states are thermodynamically stable with respect to gaseous $N_2$. Slow-heating desorption experiments with pumping show little resolution between the $\lambda$ and $\beta$ states and some evidence for depletion of the $\beta$ states resulting from population of the $\lambda$ state. Since kinetic analysis of the slow desorption spectra appeared impossible, fast heating experiments in a closed system were performed. The fast desorption spectra were computer fitted to several desorption models. While little discrimination between these models was possible, all demanded considerable depletion of the $\beta$ state to achieve a satisfactory fit. Kinetic analysis of the slow desorption data, ignoring the depleted b state, gave excellent agreement with the computer-fitted data. Some evidence is presented to show that the extent of $\beta$ depletion is a function of heating rate. Population of the $\beta$ and $\lambda$ states with different isotopes led to complete scrambling on desorption showing that both states are atomic and exist on the same crystal planes. It is suggested that the $\lambda$ and $\beta$ states represent different desorption mechanisms rather than different desorption states. The evidence for depletion of the "$\beta$ state" by population of the "$\lambda$ state" suggests that the $\lambda$-desorption mechanism is an immobile adjacent atom-pair desorption in contrast to the mobile bimolecular recombination $\beta$ mechanism. The $\lambda$-desorption mechanism is discussed and a rate equation is derived for the process. No exact demarcation between the $\lambda$ and $\beta$ mechanisms will exist, but the variation in adatom translational mobility with adatom density will play an important role in the desorption mechanism. In order to explain the complete isotopic mixing between the $\lambda$ and $\beta$ "states", it is necessary to invoke rotational mobility for the adatom pairs prior to desorption. (auth)

**22883** CHEMISORPTION OF CO ON TUNGSTEN (100): COMBINED FLASH DESORPTION AND ELECTRON-STIMULATED DESORPTION STUDY. I. Yates, J. T. Jr.; King, D. A. (Univ. of East Anglia, Norwich, Eng.). Surface Sci.; 32: No. 3, 479-505(Sep 1972).

The chemisorption of CO on a tungsten (100) single crystal surface was studied at adsorption temperatures of 295 and 195°K. A combination of flash desorption and electron-stimulated desorption (ESD) techniques was used. In CO layers produced at 295°K, the well-known $\alpha$-CO state is shown to be a superposition of two states, designated $\alpha_1$ and $\alpha_2$. The $\alpha_1$-CO state exists preferentially at higher $\alpha$-CO coverages and is characterized by a predominant ion yield of $CO^+$ upon 100-eV electron bombardment. The $\alpha_2$-CO state yields $O^+$ and consists of a number of overlapping states possessing a range of desorption activation energies. During thermal desorption of $\alpha$-CO, a stoichiometric state interconversion process occurs in which $\alpha_1$-CO converts to more strongly-held $\alpha_2$-CO as surface coverage decreases. Similar conversion behavior is observed when the surface layer is depopulated by ESD. Adsorption of CO at 195°K resembles adsorption at 295°K, except that a small additional $\alpha$-CO state, designated $\alpha_0$, and yielding $CO^+$ on ESD, is populated. Structural models are presented for $\alpha_1$-CO and $\alpha_2$-CO, and the role of surface species' structure in determining ionic fragmentation probabilities is discussed. (auth)

**22884** ADSORPTION OF OXYGEN ON W(100): ADSORPTION KINETICS AND ELECTRON STIMULATED DESORPTION. Madey, T. E. (National Bureau of Standards, Washington, D. C.). Surface Sci.; 33: No. 2, 355-376(Nov 1972).

The interaction of $O_2$ with a single-crystal W(100) surface at ~300°K was examined using a combination of techniques. A precision gas dosing system was used to deposit $O_2$ onto the crystal; the absolute accuracy in the average flux F (molecules $cm^{-2}$ $s^{-1}$) is ±6%. The initial sticking probability for $O_2$ on W(100) is effectively unity; $L_0 = 0.98 \pm 0.03$. The accuracy of this measurement arises from the fact that a known large fraction of the $O_2$ molecules entering the experimental chamber strike the crystal before reaching the mass spectrometer detector. The electron-stimulated desorption (ESD) measurements of absolute $O^+$ ion yields and energy distributions as a function of oxygen exposure were made during bombardment by 100-eV electrons. A measurable ion yield is detectable at the earliest stages of adsorption; a slight maximum in the ion yield of $\sim 5 \times 10^{-9}$ ions/electron occurs at about one half monolayer coverage. Evidence of reconstruction of the substrate at this coverage follows from this and other work. At oxygen coverages $\gtrsim 4 \times 10^{14}$ molecules $cm^{-2}$, a high-ion yield ESD state appears ($\sim 10^{-6}$ $O^+$ ions/electron). An estimate of the angular distribution of ESD-liberated $O^+$ ions was made using a primitive two-segment collector. The ion angular distribution is strongly peaked in the direction normal to the surface. The functional form of this distribution is not known, but if the distribution were of the form $\cos^n \theta$, the results are consistent with $n \gtrsim 14$. Implications of this observation for the possible identification of chemisorption sites are discussed. Work function changes and elastic electron reflection characteristics were measured for the oxygen-covered and clean W(100) surface. 39 references. (auth)

**22885** ANOMALOUS FOWLER–NORDHEIM PLOTS OF A TUNGSTEN FIELD EMITTER COVERED WITH SILICON. Sinha, M. K.; Swenson, O. F.; Venkatachalam, G. (North Dakota State Univ., Fargo). Surface Sci.; 33: No. 2, 414-418(Nov 1972).

After repeated evaporations of Si on W tips and annealing of the tips during surface migration and thermal desorption experiments, the Fowler–Nordheim plots are no longer linear. It is shown that the break in the plots is probably the result of diffusion of Si in W, induced by the electric field stress. (DLC)

**22886** ADSORBATE-INDUCED WORK FUNCTION CHANGES. Flaim, T. A.; Ownby, P. D. (Univ. of Missouri, Rolla). Surface Sci.; 32: No. 3, 519-526(Sep 1972).

The model for adsorbate-induced work function changes developed by Gyftopoulos and Levine (J. Appl. Phys., 33: 67(1962)) is shown to quantitatively predict increased work-function changes for adsorption of silicon and boron on tungsten substrates. Qualitative correlations with the resonance-tunneling model of adsorbate-induced work function changes are given. (40 references) (auth)

**22887** DIFFUSION BORONIZING OF MOLYBDENUM AND NIOBIUM IN BORON CARBIDE POWDER. Sosnovskii, L. A.; Epik, A. P.; Kraplya, A. P. (Inst. of Materials Science, Kiev). Sov. Powder Met. Metal Ceram. (Engl. Transl.); 11: No. 9, 745-747(Sep 1972).

Translated from Porosh. Met., Akad. Nauk Ukr. SSR; 11: No. 9, 75-78(Sep 1972).

A study was made of the boronizing of molybdenum and niobium in boron carbide powder with or without additions of halogen-containing activating agents. It was established that salts of hydrofluoboric acid are the most effective activating agents. The boronizing of refractory metals and alloys in commercial boron carbide powders ensures a comparatively high rate of coating formation and gives high quality of deposits. (auth)

**22888** LOW-ENERGY ELECTRON-DIFFRACTION STUDIES OF (0001) AND (1010) RHENIUM SURFACES. Zehner, D. M. Providence; Brown Univ. (1972). 147p. University Microfilms Order No. 73-2360.

Thesis (Ph.D.).

Production of clean Re (0001) and $(10\bar{1}0)$ surfaces and their adsorption of CO and $O_2$ were studied using low-energy electron diffraction, mass spectrometry, and work function changes. Clean surfaces could not be obtained by heating to 1300°C. Argon-ion bombardment and subsequent annealing at 780°C produced clean surfaces that exhibited the same two-dimensional lattice arrangement as that in bulk planes parallel to the surface. Contamination in the selvedge region was reduced by a series of cleaning treatments combined with heating at 1225°C. (DLC)

**22889** GRAIN-BOUNDARY CORROSION OF TYPE 304 STAINLESS STEEL BY CESIUM OXIDES. Maiya, P. S.; Busch, D. E. (Argonne National Lab., IL). Met. Trans.; 4: No. 3, 663-666(Mar 1973).

When austenitic stainless steel (300 series) is exposed to cesium oxides in the temperature range from 450 to 700°C, the grain boundaries are attacked preferentially. The penetration of cesium oxides into the grain boundaries of AISI Type 304 stainless steel was studied as a function of time and temperature. These investigations have established that the penetration kinetics are linear in time, the activation energy for the process is 19 kcal/mole, and the rate of penetration is fairly insensitive to carbide precipitation and precipitate composition and morphology. The kinetics of the process are approximately an order of magnitude faster than those observed for some reactor (U, Pu) oxide fuel elements clad with Type 304 stainless steel under fast-flux irradiations, and the results are discussed qualitatively. (auth)

**22890** PROTECTING METALS IN CORROSIVE HIGH-TEMPERATURE ENVIRONMENTS. Miller, F. M.; Bredzs, N. T. (Wall Colmonoy Corp., Detroit). Metal Progr.; 103: No. 3, 80; 82; 84(Mar 1973).

A family of nickel-chromium coatings used in improving the performance and service life of jet engine components and in the economical salvaging of damaged parts is described. The coatings, applied to lower-cost base metals, are also potential alternatives to expensive superalloys in automotive gas turbine, thermal reactor, and exhaust system parts. (auth)

**22891** PASSIVITY OF ZIRCONIUM IN SULFURIC ACID SOLUTIONS: EFFECT OF CATHODIC PRETREATMENT. Elayaperumal, K.; Chouthai, S. S.; Balachandra, J. (Bhabha Atomic Research Center, Bombay). Corrosion; 29: No. 2, 59-63(Feb 1973).

The effect of cathodic pretreatment at −1.3 V vs a saturated calomel electrode (SCE) on the passivity of Kroll zirconium in 5, 10, and 20 vol % $H_2SO_4$ solution at room temperature was determined through potentiostatic anodic polarization studies. The cathodic treatment made the attainment of passivity easier and reduced the passive currents considerably. Studies on potential vs time and active and passive currents vs time indicated a protective film formation during the cathodic treatment. The possibility of a zirconium oxide film formation due to cathodic polarization induced alkalinity at −1.3 V (SCE) is discussed. (auth)

**22892** CORROSION OF METALS BY LIQUID BISMUTH–TELLURIUM SOLUTIONS. Kanne, W. R. Jr. (Savannah River Lab., Aiken, SC). Corrosion; 29: No. 2, 75-82(Feb 1973).

Corrosion of candidate materials of construction for stills to extract radioactive polonium-210 from bismuth by distillation at temperatures of 450 to 950°C was evaluated. Tellurium, being chemically similar to polonium, was used as a nonradioactive stand-in for polonium. Tantalum appears to be the most satisfactory material from the standpoint of long term corrosion and fabricability. Tantalum was corroded at rates up to $2 \times 10^{-5}$ in/h during the initial 100 to 200 hours exposure; the rate decreased to below $10 \times 10^{-6}$ in/h after 400 hours for concentrations of tellurium in bismuth of less than 30%. Graphite was not attacked chemically, but was penetrated through pores. TZM alloy exhibited average corrosion rates of less than $6 \times 10^{-6}$ in/h during 500 hours exposure in less than 20% tellurium in bismuth, but corroded rapidly ($7.2 \times 10^{-5}$ in/h) in 50% tellurium. The stainless steels, particularly Type 430, might be used to approximately 550°K; but corrosion rates increased above $3 \times 10^{-5}$ in/h for a 15% solution of tellurium in bismuth at higher temperatures. (auth)

**22893** ANODIC OXIDATION OF SEVERAL RARE EARTH METALS IN SODIUM ALUMINATE SOLUTION. Gruss, L.; Mackus, T. (Frankford Arsenal, Philadelphia). J. Electrochem. Soc.; 120: No. 3, 337-340(Mar 1973).

Samarium, europium, gadolinium, yttrium, dysprosium, holmium, erbium, and ytterbium metal rods (99.9% pure) were anodized in a 0.1N solution of sodium aluminate (15°C) at constant current density of 0.16 A/cm$^2$. Anodic barrier film effects and dielectric breakdown (sparking) were observed with all of the metal–electrolyte combinations investigated. Powder x-ray diffraction patterns and diffuse reflectance spectra in the near uv to visible range were obtained for the anodic oxidation products. The anodic spark reaction process produced perovskite structured coatings on the lower atomic number samarium, europium, and gadolinium metals. Mixtures of perovskite- and garnet-structured coatings were produced on the higher atomic number dysprosium, holmium, erbium, and ytterbium metals including yttrium. (auth)

**22894** TRANSPORT NUMBERS OF METAL AND OXYGEN DURING THE ANODIC OXIDATION OF TANTALUM. Pringle, J. P. S. (Chalk River Nuclear Labs., Ont.). J. Electrochem. Soc.; 120: No. 3, 398-407(Mar 1973).

An oxide film on a metal surface will thicken only if metal, or oxygen, or both, migrate across it. The relative magnitude of the metal and oxygen migrations can be determined using markers, and the possible results are reviewed for the ideal case of a homogeneous oxide grown to uniform thickness on a plane metal surface. Such experiments require markers that are both inert and immobile; criteria are developed to establish that these requirements have been met. Experimentally, it has been shown that the anodic oxidation of tantalum is a system close to the ideal, and that the radioisotope of a noble gas is a good approximation for the required marker. Radioactive noble gases were implanted by means of a mass separator into thin films of anodic tantalum oxide, and the transport numbers of the tantalum and oxygen measured after thickening by further anodization. The transport numbers were found to be 0.243 and 0.757, respectively, for anodizing conditions of 1 mA/cm$^2$ at 25°C in 0.1M $H_2SO_4$. The noble gas concentration profiles were observed to broaden on further anodizing, and this was interpreted as being due to the simultaneous movement of tantalum and oxygen atoms during the charge-transfer event. (auth)

**22895** DECOMPOSITION OF $CO_2$ ON (100) W. Clavenna, L. R.; Schmidt, L. D. (Univ. of Minnesota, Minnesota, Minneapolis). Surface Sci.; 33: No. 1, 11-26(Oct 1972).

The binding states and condensation kinetics of $CO_2$ and its decomposition products CO and $O_2$ on (100) W are examined by flash-desorption mass spectrometry. Carbon dioxide desorbs almost entirely as CO and oxygen at all coverages. At saturation there are three major states of CO. These correspond to the high-temperature states of CO alone although all peaks are shifted and amounts are altered slightly. Carbon monoxide exhibits four major binding states. All of these obey first-order desorption kinetics as expected except the most tightly bound state which obeys second-order kinetics. Desorption from a bimolecular complex is postulated to explain these results. Initial sticking coefficients of $CO_2$, CO, and $O_2$ at 300°K are 0.85, 0.49, and 1.0 respectively. Coverage dependences indicate precursor intermediates for the states occupied at low coverages. The initial sticking coefficient of $CO_2$ varies rather slowly with substrate temperature, falling to 0.3 at 1200°K. (25 references) (auth)

**22896** OXIDATION OF W(110). I. LEED Study of the Oxide Formation at 1000 K. Avery, N. R. (Univ. of Melbourne, Parkville, Australia). Surface Sci.; 33: No. 1, 107-122(Oct 1972).

Oxidation of the (110) surface of a tungsten crystal in $2 \times 10^{-3}$ torr of oxygen at 1000°K for 80 sec revealed a LEED pattern, which exhibits a complex variation with incident electron energy. A kinematic analysis has shown that the LEED patterns result from three pairs of twin-related $WO_3(11\bar{1})$ nuclei, each faceted to pyramids exposing three well-developed (100) type surfaces. Detailed analysis of the pattern has shown that the nuclei exhibit the same monoclinic symmetry at the surface as that existing in bulk $WO_3$. A pseudo-cubic lattice constant of 7.58 ± 0.1 Å was estimated from the electron energies at which Laue back reflexion beams were excited. (auth)

**22897** KINETICS OF OXIDATION IN AIR OF HAFNIUM. Pieraggi, B.; Dabosi, F. (CNRS, Toulouse). J. Nucl. Mater.; 46: No. 2, 183-191(Mar 1973). (In French).

The oxidation kinetics in air of Van Arkel hafnium were studied between 750 and 950°C. Comparison of thermogravimetry and microhardness allows one to characterize the overall oxidation kinetics which are of parabolic type, and also the two separate kinetics, likewise parabolic, of growth of the oxide film and of dissolution of oxygen in the metal underlying the oxide. For each of these three kinetics, the rate constants are respectively given by the following relations: $K_p = 3.1 \times 10^8 \exp(-46{,}000/RT)$, $K_1 = 1.4 \times 10^6 \exp(-36{,}000/RT)$, $K_2 = 3.4 \times 10^{10} \exp(-59{,}000/RT)$. These results are in agreement with a classical diffusion model of oxygen, both in the oxide and in the metal, set up on the basis of Wagner's general theory. The activation energy of diffusion of oxygen in hafnium is 53.0 ± 2 kcal/mole. (auth)

**22898** FIELD EMISSION/FIELD-ION MICROSCOPY AS A TOOL FOR THIN FILM AND SURFACE STUDIES. Montagu-Pollock, H. M. (Univ. of Lancaster, Eng.). Thin Solid Films; 14: No. 2, 193-209(15 Dec 1972).

A review is presented of some of the uses of field emission and field-ion microscopy in the study of thin films and surfaces. Examples are chosen to show how the behavior of individual atoms on surfaces, the adsorption of gases, the surface migration of layers, and the structure of multilayer films have been investigated. The article emphasises the parameters that can be measured and the applications and limitations of the technique, rather than its mode of operation. 70 references. (auth)

**22899** CORROSION–EROSION STRENGTH OF NIOBIUM ALLOYS. Perel'man, R. G.; Govorskii, E. V. (Moscow Aviation Inst.). Fiz.-Khim. Mekh. Mater.; 8: No. 5, 53-56(1972). (In Russian).

The resistance to erosion of Nb alloys during 500 h was lowered to 20% and subsequently stabilized at that level. The erosion stability of alloy BH-3 was five times, and of alloy BH-4 was 2.6 times less than X18H9T steel under the same conditions: potassium vapor at 650°C. Tests showed that prolonged contact of Nb with K vapor requires a high purity with respect to oxygen: of the order of $10^{-4}$ weight %. (tr-auth)

**22900** HEAT-RESISTING ALLOYS OF THE COMPOUND TiAl WITH NIOBIUM AT 800 AND 1000°C. Zelenkov, I. A.; Martynchuk, E. N. (Kiev Civil Engineering Inst. of Aviation). Metallofizika; No. 42, 63-66(1972). (In Russian).

The resistance to oxidation of TiAl and its alloys in air at 800 and 1000°C was investigated. A decrease in the parameters of the $TiO_2$ lattice was noted during oxidation of the alloy 50 Ti + 50 Al. This was apparently due to dissolution in the rutile of significant amounts of Al. X-ray studies showed the presence of $Al_2O_3$ in all alloys being oxidized for 300 min at 800 and 1000°C. Alloying of TiAl with Nb increased the heat stability of the former, the maximum effect being achieved with only 5% Nb in the alloy. The presence of Nb in solid solution sharply decreased the depth of penetration of gases into the metal. (tr-auth)

**22901** STRUCTURE OF THE BORIDED LAYER AFTER DIFFUSION SATURATION BY OTHER ELEMENTS. Zemskov, G. V.; Kogan, R. L.; Shevchenko, I. M.; Vuderman, V. S. (Odessa Polytechnic Inst.). Metallofizika; No. 41, 80-87(1972). (In Russian).

Two-component coatings obtained by surface alloying of borided Fe by Ti, Zr, Cr, V, Mo, W, Al, and Si were studied by micro- and x-ray structural techniques. Analyses of the reactions between elements in the Fe–B saturating element indicated that the decisive influence on the phase composition of the diffusion layer formed showed an ability of the saturating element for boride formation and their chemical affinity for Fe. (tr-auth)

## *Preparation and Fabrication*

*Refer also to abstracts 22997 and 24225.*

**22902** (AWRE-O-55/72) PLASMA SPRAY COATING. Study and Avoidance of Anomalously Large Particles. Anthony, S. R.; Dunmar, I. W. (Atomic Weapons Research Establishment, Aldermaston (England)). Aug 1972. 21p. Dep. NTIS (U. S. Sales Only). UK 50 pence.

In the plasma powder spray-coating process, a not uncommon difficulty has been the anomalous deposition of large particles, caused by a buildup of powder on some surface in the vicinity of the flame which eventually sinters or melts and is dislodged in the form of hot aggregates or liquid droplets. These may be incorporated in the intended coating as gross inhomogeneities. A study of the mechanism of this phenomenon, termed "hailing", was made especially in the case of beryllium. Certain conditions for its avoidance are discussed. (auth)

**22903** (IS-M-3) PURIFICATION OF RARE EARTH METALS BY ELECTROTRANSPORT. Carlson, O. N.; Schmidt, F. A.; Peterson, D. T. (Ames Lab., Iowa). [nd]. 10p. (CONF-730402-2). Dep. NTIS.

From 10th rare earth research conference; Carefree, Arizona, USA (30 Apr 1973).

The principles underlying the electrotransport purification process are discussed along with those variables that affect the degree of purification attainable. The results of purification experiments on the removal of interstitial impurities from yttrium, lutetium, and gadolinium are compared with those predicted from theory. Metal purities were evaluated by resistance ratio measurements and chemical analyses. (auth)

**22904** (MLM-1963(TR)) ADHESIVE BONDING OF URANIUM. Bordes-Pages, H.; Fidelle, J. P.; Roux, C.; Rapin, M. Translated by D. Hastings and L. W. Hartzel (Mound Lab., Miamisburg, Ohio), from Adhesive Bonding, A Colloquium 20 Nov 1972. 19p. Dep. NTIS.

Uranium-238, the most abundant of the natural isotopes of uranium, was used in this study. Special attention was paid to surface preparations, the high chemical reactivity of uranium being the main reason the adhesive bonds fail to hold firm. The use of fatty acids would protect the surface from corrosion, and assembly would be possible after several months of storage without any additional surface preparation. Certain parameters still remain to be more clearly defined for the obtaining of the protective layer: influence of electrolytic polishing, concentration of the baths, rinsing, effect of environment; the result should be an improvement in the reproducibility of the surface state desired. Tests on tensile specimens and on structural adhesive bondings with several surface preparations were performed in different atmospheres: air, argon, nitrogen, and under a slight primary vacuum. After one year the results are very satisfactory (180 to 200 bar), but during the second year the corrosion effect is very noticeable and demands a better surface protection (use of fatty acids). In cases where harmful effects of radioactivity are liable to appear with time (uranium-235), a polyamido–imide varnish more radiostable than the adhesives used may be deposited on the surface, at the same time providing extra protection against corrosion. The bond may then be made with the same radiostable adhesive if polymerization can take place at high temperature (290°C), or with a conventional adhesive polymerizing at room or moderate temperature (80°C). (auth)

**22905** (ORNL-TM-4133) UNCONVENTIONAL WELDING PROCESSES: A BIBLIOGRAPHY. Stemple, R. M. (comp.). (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 68p. Dep. NTIS $5.50.

The newer methods for welding have been termed "unconventional" to differentiate them from the older ones, and include electron beam, ultrasonic, laser beam, and friction welding. This bibliography brings together the world literature on these processes through 1971. A separate section is devoted to each process, and the arrangement is by author with an introduction and key-word index. When an article or paper is authored by more than three individuals, only the first is cited. Indexing and abstracting services searched were: Applied Science and Technology Index, Chemical Abstracts, Engineering Index, International Aerospace Abstracts, Nuclear Science Abstracts, Metals Abstracts, STAR, TAB, Titanium Abstracts, and U.S. Government Reports Index. (auth)

**22906** BONDING TUNGSTEN WITH A FUGITIVE ALLOY BINDER. Binkley, N. C.; Hammond, J. P. (to United States Atomic Energy Commission). U.S. Patent 3,707,763. 2 Jan 1973. Filed date 1 Jul 1971. 4p.

A method of forming a tungsten-to-tungsten joint which comprises depositing on at least one of the faying surfaces a thin film, foil, or coating of an alloy consisting essentially of, in weight percent, 55 to 75% nickel, balance iron, pressing the faying surfaces together, heating the joint area to just above the melting point of the alloy in an inert atmosphere to produce a joint which has a remelt temperature approximating the melting point of the tungsten-base metal. (Official Gazette)

**22907** (UCRL-Trans-10674) PHYSICS OF EXPLOSIVE WELDING AND STRENGTHENING. Translated from pp 111-187 of Fizika Uprochneniya i Svarki Vzryvom, Izdatel'stvo, Nauka, Sibirskoe Otdelenie, Novosibirsk, 1972 105p. Dep. NTIS.

The book is a systematic exposition of the basic physical phenomena that accompany the processes of explosive welding and strengthening of metals. After an introduction, the five chapters cover: projection of bodies with the aid of explosives, parameters determining collisions, explosive strengthening, wave formation in oblique collisions, and main features of explosive welding. 83 references. (DLC)

**22908** EFFECTS OF DEPOSITION TEMPERATURE AND SUBSTRATE BIAS ON ORIENTATION AND HARDNESS OF THICK SPUTTER-DEPOSITED BERYLLIUM FOILS. Patten, J. W.; McClanahan, E. D. (Battelle-Northwest, Richland, WA). J. Less-Common Metals; 30: No. 3, 351-359(1973).

Sputter-deposited beryllium examined in this investigation displayed strong crystallographic textures for deposition temperatures ranging from 9 to 560°C. Texture varied with deposition temperature and substrate bias, with {002}, {100}, and {110} textures being observed. Deposit hardness ranging from 275 to 880 DPH were obtained. The data obtained in this investigation indicate that it should be possible to sputter-deposit free-standing beryllium foils with specified properties. The strong crystallographic texture of such foils should minimize dimensional instability arising from nonuniformity of texture. (auth)

**22909** SINTERED 13%-Cr STEEL FOR FAST-REACTOR FUEL ELEMENT CANS. II. $TiO_2$-Containing steels. Denisenko, E. T.; van Asbroeck, P. (Inst. of Materials Science, Kiev). Sov. Powder Met. Metal Ceram. (Engl. Transl.); 11: No. 9, 760-765 (Sep 1972).

Translated from Porosh. Met., Akad. Nauk Ukr. SSR; 11: No. 9, 95-101(Sep 1972).

Properties of dispersion-strengthened chromium steel are reviewed. Information and discussions are included on structure of sintered ferritic steels, strength of $TiO_2$-strengthened alloy steels, and creep of these steels. (JRD)

**22910** PRETSIZIONNYE SPLAVY S OSOBYMI SVOISTVAMI TEPLOVOGO RASSHIRENIYA I UPRUGOSTI. (Precision Alloys with Special Properties of Thermal Expansion and Elasticity). Rysko, S. Ya. (ed.). Moscow; Izdatel'stvo Standartov (1972). 152p.

A data reference book is presented on the chemical composition, physical, mechanical, and technological properties of special precision alloys having specific (and frequently minimum) values of thermal expansion and temperature coefficients of moduli of elasticity. The listings feature Fe, Co, and Ni alloys; a few entries contain several percent Mo and/or W. (31 references) (KSW)

**22911** PROBLEMS CONCERNING DEGASSING OF NIOBIUM–ZIRCONIUM OXYGEN-CONTAINING ALLOYS. Jehn, H.; Olzi, E. (CNR, Milan). Met. Ital.; 64: No. 11, 487-490(Nov 1972). (In Italian).

The degassing process of O-containing Nb–5 at. % Zr alloys was studied in high vacuum in the temperature range of 1900 to 2100°C. The oxygen, initially present mainly as $ZrO_2$ precipitations, is removed by the evaporation of volatile Nb oxides. The experiments show a linear decrease in oxygen content with annealing time and the process is mainly controlled by the evaporation of Nb oxide. (auth)

**22912** FORGING INCONEL 600 FOR NUCLEAR APPLICATIONS. Johnston, H. S. (Standard Steel, Burnham, PA). Metal Progr.; 103: No. 3, 62-63(Mar 1973).

Development of a forging process designed to produce fine grain structures in Inconel 600 is described. The material is heated rapidly through grain-growing temperatures. When the forging temperature is reached (2250°F maximum) the forging operation is initiated as soon as even temperature distribution occurs. During the last forging operation the temperature is lowered to 2000°F to produce fine as-forged grains. Discussions of uniform working assurance, and quality control are included. (JRD)

**22913** PRACTICAL CONSIDERATIONS IN WELDING NUCLEAR PIPING SYSTEMS. Macleod, B. M. (Bechtel Inc., San Francisco). Metal Progr.; 103: No. 3, 65-67(Mar 1973).

It is noted increasing emphasis is being placed on automated processes for welding nuclear piping systems. Use of automated welding processes in the field depends on welder skill, acceptance by labor crafts, process reliability, and cost. Practical considerations associated with both automated and manual welding of nuclear piping are discussed along with welding process selection, weld quality, and welding procedures. (JRD)

**22914** INERTIA WELDING SOLVES FASTENER PROBLEMS. Causey, W. B. (Townsend Co., Santa Ana, CA). Metal Progr.; 103: No. 3, 99; 104(Mar 1973).

Inertia welding of the Cherrybuck fastener, consisting of a Ti–6Al–AV shank joined to a ductile commercially pure Ti tail, is described. Inertia welding doesn't require a controlled atmosphere and produces an excellent forged-type structure. (JRD)

**22915** MOLYBDENUM METAL BY THE ALUMINOTHERMIC REDUCTION OF CALCIUM MOLYBDATE. Mehra, O. K.; Bose, D. K.; Gupta, C. K. (Bhabha Atomic Research Centre, Trombay, India). Met. Trans.; 4: No. 3, 691-694(Mar 1973).

A process for extracting molybdenum metal in well consolidated form and in good yield from calcium molybdate, by open aluminothermic reduction, is described. Aluminothermic molybdenum has been further processed both by electron-beam melting and by molten salt electrorefining for the removal of aluminum. The final metal compares very favorably with commercial molybdenum obtainable by other routes. (auth)

**22916** FABRICATING NUCLEAR FUEL ROD BASKETS. Miller, M. H. (International Harvester Co., San Diego, CA). Metal Progr.; 103: No. 3, 8(Mar 1973).

A fabrication process for nuclear fuel rod baskets is described in which welding and furnace brazing, precision fixturing, and roller leveling after hole punching are combined. This process can be used to fabricate fuel rod baskets that meet stringent tolerance specifications. (JRD)

**22917** SOLID-STATE WELDING OF COPPER TO MOLYBDENUM IN VACUUM. Hrivnak, I. Zvaranie; 21: No. 6, 170-172 (Jun 1972). (In Slovak).

Experiments were carried out to weld Cu bar (10-mm dia) samples to 1-mm thick Mo discs (both metals were of electrotechnical grade) in vacuum of 2 to $5 \times 10^{-5}$ torr at 950°C by high-frequency heating. Welds with Ni and Pd interlayers were also carried out. The strength of the joints was measured and plotted as a function of welding time. Microhardness was measured across the joint section. Thermal cycling at 600°C was tested. Optimum welding time of 5 min was obtained for Cu/Mo (UTS = 15 kp/mm$^2$), 10 min for Cu/Ni/Mo (UTS = 10.5 kp/mm$^2$), and Cu/Pd/Mo (UTS = 2 kp/mm$^2$). The UTS decreased after cycling and the stability of the Cu/Mo joints was better. (Metals Abstr.)

**22918** EFFECT OF SURFACE PREPARATION ON THE FORMATION OF PERMANENT JOINTS IN VNZ ALLOY BY DIFFUSION WELDING UNDER VACUUM. Abramtsev, A. V.; Kedrin, I. D.; Nichushkin, V. V. Svar. Proizv.; No. 5, 23-24(May 1972). (In Russian).

The effects of vacuum spray-coated interlayers (on the surface to be welded) on the strength of joints of VNZ alloys produced by diffusion welding in vacuum are examined. The chemical composition of VNZ alloy was (in %): 4.0 to 5.2 Mo; 0.8 to 2.0 Zr; 0.08 to 0.16 C; 0.03 $O_2$; ≤0.04 $H_2$; ≥0.005 $N_2$; balance, Nb. Nickel was used for the spray-coated interlayer. It is shown that the upper temperature limit for the joint is confined to the recrystallization temperature of niobium and its alloys. The presence of recrystallized grains does not reduce the weld strength but appears to depend on the number of gripping centers which increase with surface purity. The positive effect of the spray-coated film lies primarily in cleaning the surface rather than promoting diffusion processes. (7 references) (JPRS)

**22919** STRENGTHENING OF TITANIUM ALLOYS DURING TREATMENT IN REGIMES OF SUPERPLASTICITY. Shorshorov, M. Kh.; Tikhonov, A. S.; Kofanova, G. N. Fiz. Khim. Obrab. Mater.; No. 6, 89-94(1972). (In Russian).

The character of high-temperature deformation in regimes of superductility (small grain dimensions, a high density of lattice defects in the crystals) may be used for the hardening of alloys when regression and recrystallization are absent. The basis of the proposed hardening techniques is the deformation of heterogeneous alloys under conditions which assure maximum development of an intergranular surface of nucleating centers of a new phase with direct fixation of the structures obtained by quenching. The experimental part is concerned with the Ti alloys VT-6 (6.75% Al, 5.25% V, 0.17% Fe) and VT-14 (5.1% Al, 1.17% V, 3.0% Mo, and 0.2% Fe). (KSW)

**22920** EFFECT OF ALLOYING A NICKEL MATRIX WITH THE METAL OF REINFORCING WIRES ON THE STRUCTURAL STABILITY OF NICKEL–TUNGSTEN AND NICKEL–MOLYBDENUM COMPOSITE MATERIALS. Karpinos, D. M.; Tuchinskii, L. I.; Vishnyakov, L. R.; Pereselentseva, L. N.; Klimenko, L. N.; Deimontovich, V. B. Fiz. Khim. Obrab. Mater.; No. 6, 107-113 (1972). (In Russian).

The problem of producing structurally stable composite materials was studied for the Ni–W and Ni–Mo systems. Wires of W and Mo 0.5 mm in diameter were molded in a powdered matrix of Ni–W or a matrix of Ni–Mo, and the composites were fired at 1200°C for 5 to 6 min (insufficient time to dissolve the reinforcing wire). The wire and matrix formed an intermetallic compound in the case of the Ni–Mo matrix, and the presence of Mo in the matrix did not prevent the Mo wire from dissolving. The reinforcing W wire remained intact presumably because the Ni–W alloy was near saturation. (KSW)

**22921** HYDROEXTRUSION OF LOW-ALLOYED MOLYBDENUM ALLOYS. Mal'tsev, M. V.; Beresnev, B. I.; Yakimova, A. M.; Ezerskii, K. I.; Sautin, Yu. I.; Bulychev, D. K.; Kocherov, A. V. Fiz. Khim. Obrab. Mater.; No. 6, 129-133(1972). (In Russian).

The hydrostatic extrusion of new Mo alloys containing small amounts of other metals was studied: alloy TSM-3 (Mo–0.1% Ni, 0.1% C) and alloy TSM-4 (Mo–0.1% Ni–0.25% Zr–0.04% C). A logarithmic relationship between the critical pressure (P) and the degree of deformation ($\mu$) was noted: $P = 10 \ln \mu$ for alloy TSM-3, and $P = 7 \ln \mu$ for alloy TSM-4. A detailed investigation was made of the structure and mechanical properties of the extruded materials in the deformed and the annealed states. Annealing was conducted in a vacuum at the temperatures 1000, 1200, 1400, 1600, and 1800°C. Hydrostatic extrusion of the two Mo alloys increased their strength and ductility. Other effects are discussed. (KSW)

## *Properties, Structure, and Phase Studies*

*Refer also to abstracts 22200, 22218, 22342, 23829–23831, and 23835.*

**22922** (AD-875947) CRACK-PROPAGATION STUDIES IN BERYLLIUM SINGLE CRYSTALS AND CALCULATIONS OF SOLUBILITY LIMITS IN DILUTE BERYLLIUM ALLOYS. Final Technical Report, 1 March 1969–31 July 1970. Damiano, V. V.; Lalevic, B.; London, G. J. (Franklin Inst. Research Labs., Philadelphia, Pa.). Aug 1970. 151p. (AFML-TR-70-206). NTIS.

Crack propagation was studied in three purity levels of beryllium single crystals. Cracks were initiated at the base of a notch and propagated on the (0001) and (11-20) planes. The effect of temperature on the propagation and blunting of cracks was examined. The propagation of cracks on the (0001) planes is less sensitive to purity than propagation on the (11-20) planes. Although cracks are readily propagated on the (0001) planes in high-purity beryllium at 350°C, they are easily blunted at room temperature on the (11-20) plane. The band structure energy was computed as a function of the axial c/a ratio for hcp metals, such as Be, Mg, and Zn and for their dilute alloys with Cu, Ag, Au, and Li. A theoretical criterion was obtained for the solubility limits for hcp metals, which is in agreement with experiments. It was found that in order to form a ternary alloy with Be–Cu, the third element should have a very broad form factor such as in thallium or indium. It was demonstrated the stability of hcp phase of Be and Mg and their dilute alloys and shown that fcc structure and at the formation of stacking faults is quite unlikely in Be–Cu alloy. Finally, a method was obtained to judge the validity of the different forms of pseudopotential and thus come closer to the explanation of the observed phase diagrams of metals. (auth)

**22923** (AECL-4308) THERMO-ELASTIC DEFORMATIONS IN A SEGMENT OF A HOLLOW NONCIRCULAR CYLINDER. Crozier, R. J. M. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs). Nov 1972. 74p. Dep. NTIS (U. S. Sales Only). AECL $2.00.

A numerical technique is described that is used to determine the thermo-elastic deformations experienced by a segment of a hollow, noncircular cylinder whose inner and outer surfaces are subjected to temperatures, radial and tangential displacements, and normal and shear pressures, all of which may vary around the circumference of the cylinder. The report is intended as a users' manual for the Fortran program CHANTER which has been written to carry out the necessary computations. The problem of the determination of the thermo-elastic stresses in an out-of-round fuel sheath whose inner surface is deformed by a cracked fuel pellet is used as an illustration. (auth)

**22924** (BNWL-SA-4146) STRENGTH DIFFERENTIAL EFFECT IN $\alpha$-PLUTONIUM. Merz, M. D. (Battelle Pacific Northwest Labs., Richland, Wash.). 1972. 8p. (CONF-720670-1). Dep. NTIS.

From Strength differential effect in metals and polymers conference; Boston, Massachusetts, USA (20 Jun 1972).

The strength-differential effect (SD effect) in monoclinic $\alpha$-Pu was studied by examining the difference in tensile and compressive strengths. Microstructural changes during deformation were significantly different for tension and compression. In compression the grain size became larger in the center of the specimens where the strain was highest; there was a corresponding hardness increase. However, in tension no grain size increases were observed; only disappearance of some of the larger grains present before testing. These observations may be those of a secondary effect due to differences in flow stress for compression and tension but they do suggest that recrystallization and/or grain growth are important factors in the SD effect in $\alpha$-plutonium. The effect of crystallographic texture may have bearing on the SD effect in $\alpha$-plutonium. The extruded plutonium had a strong fiber texture with the (020) planes normal to the stress axis applied during testing. Texture can affect the incidence of mechanical twinning, which has been reported to occur to a limited extent in random oriented $\alpha$-plutonium. Twinning as a deformation mode can depend on the sense of the shear stress relative to crystallographic directions and might be favored by a tensile stress normal to (020) planes compared with compressive stress normal to the same planes. Further tests on randomly oriented specimens and transverse tests on textured specimens may resolve this point. (auth)

**22925** (CONF-721104-6) FATIGUE OF PRESSURE VESSEL IN HIGH-TEMPERATURE AQUEOUS ENVIRONMENT. Kondo, T. (Japan Atomic Energy Research Inst., Tokai. Tokai Research Establishment). 1972. 22p. (In Japanese). Dep. NTIS (U. S. Sales Only).

From INCO Power Conference; Kyoto, Japan (28 Nov 1972).

Fatigue behavior of reactor pressure vessel steels, ASTM A302B and A533B, in high-temperature aqueous environment was studied. Some factors affecting crack-growth characteristics of these steels, e.g., stress or strain conditions, temperature, and loading frequency were investigated. The crack-growth rate in high-temperature aqueous environment, as well as in ambient-air environment, was strongly dependent on the stress, but the growth characteristics were substantially different. The crack growth rate in aqueous environment was also greatly influenced by temperature and loading frequency. Prediction of the life of full-size pressure vessels under corrosive condition applying specimen data was proposed. (auth)

**22926** (CONF-721104-8) TEST RESULTS OF STRUCTURAL MATERIALS FOR IN-PILE AND OUT OF PILE HIGH TEMPERATURE HELIUM GAS LOOPS. Nomura, S.; Fujimura, T.; Itami, H.; Yamamoto, K.; Muraoka, S.; Kita, K. (Japan Atomic Energy Research Inst., Tokai; Kawasaki Heavy Industries Ltd., Kobe (Japan)). 1972. 9p. (In Japanese). Dep. NTIS (U. S. Sales Only).

From INCO Power Conference; Kyoto, Japan (28 Nov 1972).

Results of testing of heat resisting alloys for use in high-temperature He gas loops are presented. Welding methods are also discussed along with results of irradiation experiments. (JRD)

**22927** (CONF-721104-10) MATERIALS TRENDS IN POWER GENERATING TURBINE PLANTS. Yoshida, H. (Tokyo Shibaura Electric Co. LTD., Kawasaki, Kanagawa Prefecture (Japan)). 1972. 19p. (In Japanese). Dep. NTIS (U. S. Sales Only).

From INCO Power Conference; Kyoto, Japan (28 Nov 1972).

A review of thermal power plant in Japan is presented. Information is included on materials used in boilers, corrosion, boiler failure causes, turbine failure causes, and power plant operational parameters. (JRD)

**22928** (COO-3459-2) PRECIPITATION AND DISPERSION HARDENING IN HCP ALLOYS. Annual Report. Stoloff, N. S. (Rensselaer Polytechnic Inst., Troy, N. Y.). 1 Feb 1973. Contract AT(11-1)-3459. 13p. Dep. NTIS.

Results of studies on properties and structure of Hf–3% Zr, Mg–3.7% Th–0.6% Zr and a eutectic Mg–Al alloy are reported. Information is included on the effects of H and O on the yield strength of Hf, effects of aging treatments on the Mg–3.7% Th–0.6% Zr, and results of tensile tests on the Mg–Al eutectic. (JRD)

**22929** (HEDL-SA-243) EFFECT OF FREQUENCY UPON THE FATIGUE-CRACK GROWTH OF TYPE 304 STAINLESS STEEL AT 1000°F. James, L. A. (Hanford Engineering Development Lab., Richland, Wash.). Contract AT(45-1)-2170. 19p. (CONF-710850)-2). Dep. NTIS.

The fatigue-crack growth rate of Type 304 stainless steel was studied at 1000°F with cyclic frequencies ranging over approximately 4½ orders of magnitude. It was found that as frequency decreased the fatigue-crack growth rate showed a significant increase, and the behavior could be characterized by an equation of the form $da/dN = A(f)\ [\Delta K]^n$, where the exponent n represents a constant for all of the frequencies studied. (auth)

**22930** (HEDL-TME-72-153) EFFECT OF PRIOR CREEP STRAIN ON RESIDUAL MECHANICAL PROPERTIES OF 20 PERCENT COLD WORKED TYPE 316 STAINLESS STEEL (RM-30). Paxton, M. M. (Hanford Engineering Development Lab., Richland, Wash.). Jan 1973. 25p. AT $4.00.

The effects of prior creep strain on the residual tensile, tube burst, uniaxial creep and biaxial stress to rupture properties of 20% cold-worked Type-316 stainless steel tubing are evaluated. For relatively low creep strain (<2%) tensile and burst strength are moderately lowered and ductility is increased. For larger creep strain (>10%), the decrease in engineering strength and ductility can be attributed to changes in specimen dimensions and failure mode. Creep properties are essentially enlarged by a change in the direction of maximum principal stress. (auth)

**22931** (NASA-CR-120833) PROTECTIVE CLADDINGS FOR HIGH-STRENGTH CHROMIUM ALLOYS. Collins, J. F. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). 15 Sep 1972. 76p. Dep. NTIS (U. S. Sales Only).

The application of a Cr–Y–Hf–Th alloy as a protective cladding for a high-strength Cr alloy was investigated for its effectiveness in inhibiting N embrittlement of a core alloy. Cladding was accomplished by a combination of hot-gas pressure bonding and roll-cladding techniques. Based on bend ductile–brittle transition temperature (DBTT), the cladding alloy was effective in inhibiting N embrittlement of the Cr core alloy for up to 200 h in air at 1422°K. A significant increase in the bend DBTT occurred with longer time exposures at 1422°K or short time exposures at 1589°K. (Metals Abstr.)

**22932** (NRL-7439) FRACTURE SAFETY CONSIDERATIONS FOR HANFORD-N REACTOR COOLANT PIPING MATERIAL. Gray, R. A. Jr.; Loss, F. J. (Naval Research Lab., Washington, D. C.). 1 May 1972. Contract AT(49-5)-2110. 16p. Dep. NTIS.

A proposal was made to lower the temperature of makeup injection water in the Hanford-N reactor coolant piping to achieve a more economical operation. A second proposal calls for freezing a plug of water in a large-diameter pipe to permit valve repairs. Implementation of either proposal enforces a degradation in fracture toughness, since the latter is temperature-dependent. The toughness of A106-B and A212-B pipe materials was characterized by the Dynamic-Tear test procedures. The toughness trends evolved were used to assess the fracture safety of the proposed operations. (auth)

**22933** (ORO-4044-3) STUDIES OF MICROSTRUCTURE-PROPERTY RELATIONSHIPS IN AUSTENITIC STAINLESS STEELS. Technical Progress Report, February 1, 1972–December 31, 1972. Spruiell, J. E. (Tennessee Univ., Knoxville. Dept. of Chemical and Metallurgical Engineering). [nd]. Contract AT(40-1)-4044. 94p. Dep. NTIS.

Research on relations between microstructure and properties of austenitic stainless steels is summarized. Research results are presented on stability of Type 316 stainless steel, grain refinement in austenitic stainless steel by pulse heating, precipitation reactions in Types 316 and 321 stainless steel, and mechanical properties of Type 316 stainless steel. (JRD)

**22934** (UCLA-34-P-172-8) PARTICLE SIZE DISTRIBUTION EFFECTS IN PRECIPITATION HARDENING. Fourth Annual Progress Report for the Contract Period January 1, 1972–December 31, 1972. Ardell, A. J. (California Univ., Los Angeles. Dept. of Materials). Jan 1973. Contract AT(04-3)-34. 43p. (UCLA-ENG-7310). Dep. NTIS.

The variation of solute content during coarsening of the $\gamma'$ precipitate in four Ni–Al alloys containing 7, 8, 9, and 9.9 wt % Al aged at 800°C was studied by measuring the ferromagnetic Curie temperature as a function of aging time using our induction bridge apparatus. Whereas theory predicts that the slope of the curve of wt fraction Al vs. $(\text{time})^{-1/3}$ should decrease with increasing volume fraction, no such effect was observed, as the slopes for all four alloys were the same. These data are therefore consistent with previous studies involving measurements of the average $\gamma'$ particle size vs. time insofar as no effect of volume fraction is observed. The reasons for the discrepancy between theory and experience remain obscure. For the precipitation-hardening studies, which involve the preparation of single crystal Ni–Al alloy compression specimens, effort during the past contract period was devoted to developing several techniques, which are described. These include the argon arc-melting of the high-purity alloys, the design and construction of the modified Bridgeman apparatus for growing single crystals using rf heating, and the restoration of an Agietron electric spark-discharge machine for the machining of oriented compression specimens from the single crystals. Considerable progress was made on the new program on void formation in proton-irradiated $\gamma/\gamma'$ alloys. An irradiation chamber was designed and constructed for use on a 2-MeV Van de Graaf proton accelerator housed in the UCLA Physics Department. A technique for looking at irradiated foils edge on, in which the foils are sandwiched between layers of nichrome deposited by high-rate physical vapor deposition, has been nearly perfected. Some preliminary observations on the proton irradiation of overaged Ni–7% Al and Ni–6.5% Si alloys are presented. A theoretical analysis is presented that explains the extended ranges of protons in solids containing voids and that enables calculation of corrected values for the variation of average proton energy with distance from the specimen surface. (auth)

**22935** (UCRL-51182) DIFFUSIVITY AND SOLUBILITY OF NITROGEN IN MOLYBDENUM AND THE TRAPPING OF NITROGEN BY CARBON IN MOLYBDENUM. Weaver, D. E. (California Univ., Livermore. Lawrence Livermore Lab.). 25 Oct 1972. Contract W-7405-eng-48. 84p. Dep. NTIS. Thesis.

By employing ultrahigh-vacuum techniques, the outgassing kinetics of nitrogen-saturated molybdenum were determined over a wide range of temperatures (1050 to 1925°C) and saturation pressures (0 to 760 torr) using both single and polycrystalline samples containing various amounts of carbon (<2 to 430 wt ppM). It was found that the degassing rate is strictly diffusion-controlled under all conditions studied, thus allowing the diffusivity and the solubility of N in Mo to be calculated from the kinetic data. For high-purity, zone-refined single crystals as well as decarburized polycrystalline Mo containing <3 ppM C, the temperature dependence of the diffusivity of N is well represented by $D = (2.98 \pm 0.4) \times 10^{-3} \times \exp[(-24{,}500 \pm 230)/RT]$ cm$^2$/sec and the solubility of N in Mo by $S = (3.6 \pm 0.7) \times 10^4 P^{1/2} \times \exp[(-19{,}100 \pm 520)/RT]$ at. ppm/atm$^{1/2}$, P being the N pressure in atmospheres. Pronounced trapping effects have been observed when C is present in amounts exceeding the solubility limit. Trapping is manifest by: (1) anomalously low values of the diffusion coefficient, together with a significantly higher activation energy for N diffusion; and (2) high apparent values of the solubility. When C is all in solution instead of in second-phase precipitates, both the diffusivity and solubility of N are the same as for C-free samples. A model has been developed which explains the trapping effects caused by the second-phase carbide precipitates. This model assumes that the diffusing N is trapped by the bulk of the carbides, and that the N can diffuse in the carbide. (auth)

**22936** (UCRL-51346) FLOW BEHAVIOR OF MULBERRY URANIUM. Hoge, K. G.; Kuhn, B. A.; Reshenk, V. L. (California Univ., Livermore. Lawrence Livermore Lab.). 13 Feb 1973. Contract W-7405-eng-48. 14p. Dep. NTIS $4.00.

The mechanical properties of mulberry uranium were studied at strain rates from $10^{-4}$ to $5 \times 10^3$ sec$^{-1}$ and at temperatures from 78 to 770°K. The nonlinear loading and off-loading characteristics of this alloy received particular attention. This nonlinear behavior is the result of a $\gamma_s$ to $\gamma_0$ phase transformation and a reversible, diffusion-controlled ordering effect. (auth)

**22937** SAMARIUM–GOLD AND DYSPROSIUM–GOLD ALLOY SYSTEMS. McMasters, O. D.; Gschneidner, K. A. Jr. (Ames Lab., Iowa). J. Less-Common Metals; 30: No. 3, 325-342(1973).

Phase diagrams of the samarium–gold and dysprosium–gold alloy systems based on microscopic, differential-thermal, and x-ray-diffraction analyses are proposed. Six intermetallic compounds, $Dy_2Au$, DyAu, $DyAu_2$, $DyAu_3$, $DyAu_{3.6}$ and $DyAu_6$, form in the Dy–Au system. DyAu, $DyAu_2$ and $DyAu_3$ melt congruently and the other three decompose peritectically. Four eutectic points exist at 21.0 at. % Au and 935°C, 62.0 at. % Au and 1235°C, 73.0 at. % Au and 1185°C, and 90.5 at. % Au and 808°C. In the Sm–Au system two compounds with tentative stoichiometries, $Sm_6Au_7$ and $Sm_7Au_{10}$, were found in addition to the six with the Dy–Au stoichiometries. SmAu, $SmAu_2$ and $SmAu_{3.6}$ melt congruently while the remaining five compounds decompose peritectically. The four eutectic points are 19.0 at. % Au and 705°C, 63.5 at. % Au and 1080°C, 72.0 at. % Au and 1085°C, and 88.5 at. % Au and 770°C. $SmAu_3$, SmAu and DyAu are dimorphic. The terminal solid solubilities are given and the crystallographic data for the compounds are presented. The lattice parameters of $SmAu_3$ as compared to those of the other trivalent $RAu_3$ compounds are anomalous, suggesting the electron distribution in $SmAu_3$ is different from that in the other $RAu_3$ phases. (auth)

**22938** RARE-EARTH INTERMEDIATE PHASES WITH CADMIUM. Bruzzone, G.; Fornasini, M. L.; Merlo, F. (Univ., Genoa). J. Less-Common Metals; 30: No. 3, 361-375(1973).

The behavior of all rare-earth metals with cadmium was studied for the following compositions: $MCd_3$, $MCd_4$, $M_2CD_9$~, $MCd_6$ and $M_2Cd_{17}$. The crystal structure of these phases was determined together with that of $ThCd_{11}$. A survey of all R. E.–Cd intermetallic compounds is given. Structural and geometrical relations among the types of structure occurring are examined. (auth)

**22939** PHASE EQUILIBRIA IN THE SYSTEM RUTHENIUM–TITANIUM-HAFNIUM. Gulamova, D. D.; Raevskaya, M. V.; Sokolovskaya, E. M. Vestn. Mosk. Univ., Ser. II. Khim.; 13: No. 5, 546-550(1972). (In Russian).

Phase diagrams of systems containing these elements are presented along with tables containing data on intermetallic crystal structures and high-temperature properties. (JRD)

**22940** MEASUREMENT OF THE ELECTRIC PROPERTIES OF CERAMIC MATERIALS AT HIGH TEMPERATURES IN A REACTOR. Gulyamov, U. G.; Kostyukov, N. S.; Polyak, Yu. V.; Sokolov, A. P. (Inst. of Nuclear Physics, Kiev). Izv. Akad. Nauk Uzb. SSR, Ser. Fiz.-Mat. Nauk; No. 5, 46-48(1972). (In Russian).

An experimental channel was designed to be heated by reactor radiation and fission rather than by Nichrome of other heating elements. Experimental measurements of the electric conductivity of ceramics using Mo electrodes were conducted in a reactor (VVR-S). A cylindrical rod of W containing 2% B developed heat through the reaction $^{10}B(n,\alpha)^7Li$. Diagrams of the experimental channel and of the measuring circuitry are given. (KSW)

**22941** USE OF ASA F56 SHEET IRON FOR THE CONSTRUCTION OF THE CONTAINMENT LINER OF THE BUILDING FOR A NUCLEAR ELECTRIC PLANT. Lancellotti, G. (CIMI, Milan); Raggi, F. Atti Notiz. (Publ. in Met. Ital.); 27: No. 11, 291-296 (Nov 1972). (In Italian).

The steel ASA F56 found a prominent use in the construction of the primary containment of the nuclear electric plant ENEL at Caorso. Its improved mechanical characteristics met all required demands of the project and caused ASA F56 to be favored over ASTM type A537, Grade B, which was initially prescribed. Experience with ASA F56 in welded construction of the containment has confirmed the wisdom of this choice. (KSW)

**22942** PLUTONIUM-DOKUMENTATION. Referate-Zeitschrift mit Anhang Transplutonium-elemente. December 1972. Band 6, Heft 12. 225 Referate (Register-Nr. 3819-4245), 96 Referate (Register-Nr. 854 T-949 T). (Plutonium-Documentation. Abstract Journal with Appendix on Transplutonium Elements. December 1972. Vol. 6, No. 12. 225 Abstracts (Register No. 3819-4245), 96 Abstracts (Register No. 854 T-949 T)). Karlsruhe, Ger.; Gesellschaft fuer Kernforschung mbH (1972). 144p. (In German and English).

**22943** PLUTONIUM-DOKUMENTATION. Referate-Zeitschrift mit Anhang Transplutonium-elemente. Band 6, Heft 7-9. 3. Vierteljahresregister 1972. (Plutonium-Documentation. Abstract Journal with Appendix on Transplutonium Elements. Vol. 6, No. 7-9. 3rd Quarter Index). Karlsruhe, Ger.; Gesellschaft fuer Kernforschung m.b.H. (1972). 65p. (In German and English).

**22944** PLUTONIUM-DOKUMENTATION. Referate-Zeitschrift mit Anhang Transplutonium-Elemente. November 1972. Band 6, Heft 11. 233 Referate (Register-Nr. 3416-3818), 99 Referate (Register-Nr. 755 T-853 T). (Plutonium-Documentation. Abstract Journal with Appendix on Transplutonium Elements. November 1972. Vol. 6, No. 11. 233 Abstracts (Register No. 3416-3818), 99 Abstracts (Register No. 755 T-854 T)). Karlsruhe, Ger.; Gesellschaft fuer Kernforschung m.b.H. (1972). 135p. (In German and English).

**22945** INFLUENCE OF PRESTRAIN AT HIGH PRESSURE ON FRACTURE STRESS OF ORDERED FeCo–2% V. Timmins, P. F. (British Steel Corp., Sheffield). Scr. Met.; 7: No. 3, 243-244(Mar 1973).

Tensile tests were carried out at room temperature at superposed hydrostatic pressures up to 0.3 GN/m$^2$ and a strain rate of $1.7 \times 10^{-4}$ s$^{-1}$. Failure always occurred by transgranular cleavage, and crack propagation was the critical event. Unprestrained FeCo–2% V failed at 1.3 GN/m$^2$, ~25% prestrain had little effect on the fracture stress (1.37 GN/m$^2$). While unprestrained material extended plastically ~19% before fracture, the prestrained specimen fractured without any plastic extension. (DLC)

**22946** STRESS-RELAXATION EXPERIMENTS. Rohde, R. W.; Nordstrom, T. V. (Sandia Labs., Albuquerque, NM). Scr. Met.; 7: No. 3, 317-322(Mar 1973).

Experiments were conducted on Mo, Ta, Cu, Fe–0.7% Ti, and Cu–1.8% Be to determine whether the dislocation density remains constant during a stress relaxation test. The relaxation experiments were performed on Instron and MTS machines; the value of $\beta = \delta \ln \dot{\epsilon}/\delta\sigma$ was always greater in the Instron experiments than in the MTS experiments, indicating that work hardening was occurring during relaxation. Macroscopic work hardening coefficients were derived for each material, but this simple analysis for the structural change during relaxation is only partially successful. The immobilization parameter $\phi$ and its uniqueness are discussed. The effects of machine stiffness are discussed. The use of stress relaxation to determine the stress dependence of dislocation velocity is questioned. (DLC)

**22947** CALCULATION OF THE ELASTIC ANISOTROPY OF Ti–6Al–4V ALLOY SHEET FROM POLE FIGURE DATA.

Olsen, R. H.; Moreen, H. A. (Boeing Co., Seattle). Met. Trans.; 4: No. 3, 701-705(Mar 1973).

A technique for the calculation of the elastic modulus of Ti-6Al-4V sheet based upon pole-figure data and single-crystal elastic constants was developed. The technique uses pole figures based upon the Lopata and Kula method, the Schmid and Boas approximation for Youngs modulus, and uses a Reuss averaging technique. Comparison of the resultant values to experimentally determined modulus showed excellent agreement. Examples of the technique to the evaluation of various lots of commercial sheet material are presented. (22 references) (auth)

**22948** OBSERVATION OF VACANCY SOURCES DURING SUBSTANTIAL DIFFUSION IN THORIATED NICKEL ALLOYS. Whittenberger, J. D. (Lewis Research Center, Cleveland). Met. Trans.; 4: No. 3, 715-725(Mar 1973).

Various solid/solid diffusion couples were assembled from thoriated and nonthoriated alloys, welded, and diffusion annealed at 1530°K. Concentration profiles of the diffused couples indicated that a thoria dispersion does not affect diffusion in Cr(alloy)/Ni and Ni-4.8Al/Ni types of couples unless a fine grain structure is retained by the thoria particles. Metallography revealed the presence of $ThO_2$-free bands in the thoriated nickel side of the diffusion zone. The bands formed at grain boundaries perpendicular to the direction of diffusion and, in some cases, contained non-Kirkendall porosity. A mechanism based on the operation of vacancy sources is proposed to explain the $ThO_2$-free bands. (auth)

**22949** EXPERIMENTAL OBSERVATIONS OF TENSILE FRACTURE IN UNIDIRECTIONAL BORON FILAMENT REINFORCED ALUMINUM SHEET. Herring, H. W. (Langley Research Center, Hampton, VA); Lytton, J. L.; Steele, J. H. Jr. Met. Trans.; 4: No. 3, 807-817(Mar 1973).

Results are presented from an experimental study of the tensile fracture process in unidirectional boron filament-reinforced aluminum sheet. The tensile strength of the material was apparently limited by a noncumulative fracture mechanism which involved the initiation and sustenance of a chain reaction of filament fractures at a relatively low stress level. Matrix fracture followed in a completely ductile manner. The minimum filament stress for initiation of the fracture mechanism was shown to be approximately 170 ksi for well bonded composite having a pure aluminum matrix. This value appeared to be independent of filament diameter, number of filament layers, and filament volume fraction within the range investigated (0.2 to 0.5). Several commonly observed features of tensile fracture surfaces were explained in terms of the observed noncumulative fracture mechanism. (auth)

**22950** IMPORTANCE OF SLIP MODE FOR DISPERSION-HARDENED $\beta$-TITANIUM ALLOYS. Hamajima, T. (Rutgers—The State Univ., New Brunswick, NY); Luetjering, G.; Weissmann, S. Met. Trans.; 4: No. 3, 847-856(Mar 1973).

The mechanical properties of Ti-7Mo-7Al and Ti-7Mo-16Al (in at. %) were correlated to the microstructure. The mechanical properties of the alloy with low aluminum content, consisting of $\alpha + \beta$ phases, were dependent on the size of the $\alpha$ particles. Although the $\alpha$ phase is softer than the $\beta$ phase, the small $\alpha$ particles, upon plastic deformation of the alloy, functioned as typical hard agents in a dispersion-hardened system and the volume fraction of the particles controlled the macroscopic ductility. A rapid strain-hardening behavior of the small $\alpha$ particles seemed to be responsible for this effect. Large $\alpha$ particles behaved like soft, incoherent particles, the volume fraction having little effect on the inherent ductility of the alloy. The two-phase ($\beta + Ti_3Al$) microstructure of the alloy with high aluminum content resulting from high temperature aging to 900°C exhibited a yield stress of 130 ksi and an elongation to fracture of 5%. The ductility of this microstructure was controlled by the volume fraction of the $Ti_3Al$ particles inducing homogeneous slip. The favorable ductility properties of the microstructures with low $Ti_3Al$ volume fraction were lost if the slip mode was changed from homogeneous slip to planar slip. (auth)

**22951** EFFECT OF COOLING RATE ON PRECIPITATE HABIT PLANES IN Hf-H ALLOYS. Straw, R. L.; Stoloff, N. S. (Rennselaer Polytechnic Inst., Troy, NY). Met. Trans.; 4: No. 3, 878-882(Mar 1973).

Reactor-grade Hf (3.6 wt % Zr, 75 ppM O) was successively strained and annealed, hydrogen was introduced at levels of 0.18 to 6 at. %, and the samples were cooled at different rates. Results show that $\{10\bar{1}0\}$ hydride habit planes result from slow cooling, while (0001) planes result from rapid cooling. Electron transmission microscopy and x-ray diffraction were used to identify the hydride precipitates, and stereographic projections are given. Results are discussed with relation to Zr-H, and hydride habit planes in Zr and Hf are summarized in a table. It is concluded that precipitates in both slow-cooled and rapidly cooled samples are fct ($a_0 = 4.702$ Å, $c_0 = 4.678$ Å). The hydride habit plane in Hf is dependent on cooling rate but not on hydrogen level. (DLC)

**22952** MECHANICAL PROPERTIES OF SHEET COLUMBIUM (NIOBIUM) ALLOY SU31. Tavassoli, A. A. (Marshall Space Flight Center, Huntsville, AL). Met. Trans., 4: No. 3, 876-878 (Mar 1973).

Preliminary data are given for the mechanical properties of sheet SU31 (18.7 wt % W, 3.6 wt % Hf, 0.1 wt % Zr) for space shuttle and space tug use. The material was tested in the as-received, silicide-coated, welded, and heat-treated conditions. Bend transition temperatures and tensile properties at 0 to 2600°F were measured. Results show that SU31 is superior in overall tensile strength and ductility to other Nb alloys. (DLC)

**22953** MATERIALS SELECTION FOR GAS-COOLED REACTORS. Hedgecock, P. D. (Gulf General Atomic Co., San Diego, CA). Metal Progr.; 103: No. 3, 75-77(Mar 1973).

Specifications for metallic and nonmetallic materials for use in gas cooled reactors are discussed. The materials include high-nickel alloys, carbon steels, high-strength low-alloy steels, prestressed concrete, and ceramic-fiber insulation. Selection and use of materials in fabrication of reactor vessels, cavity liners, thermal barriers, steam generators, and control rods are discussed. (JRD)

**22954** MECHANICAL PROPERTIES OF ALLOYS OF THE IRON-ALUMINUM-MOLYBDENUM SYSTEM. Birun, N. A.; Selisskii, Ya. P. Sb. Tr. Tsent. Nauch.-Issled. Inst. Chern. Met.; No. 78, 190-197(1971). (In Russian).

Mechanical properties were determined at 25-50°C intervals over the range 20 to 800°C for five Fe-Al-Mo alloys with compositions in the $\alpha$ ternary solid-solution region along two sections, i.e. $Fe_3Al-Fe_3Mo$ and $Fe_3Al-Mo_3Al$. In the $Fe_3Al$ alloy, Mo $\leq$ 5% was introduced instead of Al or Fe. The best complex of properties was given by the ordering alloy $Fe_3(Al, Mo)$, Mo 5 and Al 20 at.-% and Fe balance. The ultimate tensile strength did not decrease rapidly with temperature; there was, in fact, an increase in strength of $\leq$90 kg/mm$^2$ at 450°C, and it remained hard in the range 20 to 500°C. It possessed good oxidation resistance at 1200°C, was resistant to corrosion in sea water, showed good stability against wear, and had a high value of $\rho$ (1.5 $\Omega$ mm$^2$/m). (Metals Abstr.)

**22955** EXPERIMENTAL DETERMINATION AND CALCULATION OF EXCESS THERMODYNAMIC FUNCTIONS OF MOLYBDENUM SOLID SOLUTIONS IN GAMMA-URANIUM. Vamberskii, Yu. V.; Udovskii, A. L.; Ivanov, O. S. (Inst. of Metallurgy, Moscow). J. Nucl. Mater.; 46: No. 2, 192-206(Mar 1973).

The thermodynamic properties of the uranium-molybdenum system were investigated in a temperature range from 1048 to 1173°K by means of the emf method with a liquid electrolyte. The excess thermodynamic functions were shown to change their signs depending on the concentration. The concentration dependencies of the excess entropy, enthalpy, and free energy of mixing of the solid solution were calculated for the above system at 1100°K on the basis of new physical concepts advanced for the solid solution. The calculated dependencies are in good (for entropy) and satisfactory (for the enthalpy and free energy of mixing) qualitative agreement with the experimental results. An interpretation is offered to explain the double change of sign of the excess entropy of mixing and the change of sign of the enthalpy of mixing as a function of the concentration. (41 references) (auth)

**22956** METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA TSVETNYKH METALLOV I SPLAVOV. (Metallurgy and Heat Treatment of Nonferrous Metals and Alloys). Kolachev, B. A.; Livanov, V. A.; Elagin, V. I. Moscow; Izdatel'stvo Metallurgiya (1972). 480p.

The book deals with the general problems of metallurgy and heat treatment of nonferrous metals, such as aluminum, magnesium, copper, titanium, zirconium, beryllium, high-melting metals, and their alloys. Among the topics discussed are the structural and mechanical properties of nonferrous metals, as well as corrosion stability, physical properties, technology of metals and alloys, and the application of these metals in the economy. References are included at the end of each chapter. (JPRS)

**22957** INVESTIGATION OF MONO- AND POLYCRYSTALLINE MOLYBDENUM STRUCTURE BY COLOR ETCHING. Savitskii, E. M.; Burkhanov, G. S.; Lapshina, L. G.; Ottenberg, E. V.; Kataev, R. S. Izv. Akad. Nauk SSSR, Metal.; No. 3, 169(May 1972). (In Russian).

The method of color etching was used for the study of Mo structure and facilitated the determination of the predominant orientation of the grain in crystallized Mo ingots. The dicarbide, oxide, and $\sigma$ phases were identified by the color-etching method. (tr-auth)

**22958** PHASE FIELDS BOUNDARIES IN THE W–Ta–Ti SYSTEM AT 1600°C. Tolmacheva, Z. I.; Kornilova, V. I. Izv. Akad. Nauk SSSR, Metal.; No. 3, 211-214(May 1972). (In Russian).

The isothermal section of the phase composition diagram at 1,600°C was constructed for the system W–Ta–Ti using metallographic and x ray data. The liquidus and solidus were projected onto the triangular concentration diagram. (tr-auth)

**22959** Er–Rh SYSTEM. Ghassem, H.; Raman, A. (Louisiana State Univ., Baton Rouge). Met. Trans.; 4: No. 3, 745-748(Mar 1973).

The phase equilibria and crystal structures of phases in the binary alloys containing erbium and rhodium were studied by conventional methods. Eight intermediate phases occur in the system: $Er_3Rh$ ($Fe_3C$ type), $Er_7Rh_3$($Th_7Fe_3$), $Er_5Rh_3$ (low-temperature), $Er_5Rh_3$ (high-temperature) ($Mn_5Si_3$), $Er_3Rh_2$, ErRh(CsCl), $ErRh_2$($MgCu_2$), and $ErRh_5$ (high temperature) ($CaZn_5$). The former five are formed through peritectic reactions between the liquid phase and the corresponding, adjacent rhodium-rich intermediate phase of the system at about 1080, 1110, 1175, 1250, and 1300°C, respectively, while the latter three are assumed to melt congruently at some temperatures above 1400°C. Four eutectics occur in the system: at 8 at. % Rh and 1020 ± 20°C; at about 60 at. % Rh and 1240°C; the other two in the rhodium-rich region, one near 80 at. % Rh and the other near 90 at. % Rh, at temperatures above 1400°C. $ErRh_5$($CaZn_5$) undergoes a eutectoid transformation into $ErRh_2$($MgCu_2$) and Rh(+Er). Contractions are observed in all the intermediate phases of the system, and based on observations of their mean atomic volumes it is postulated that rhodium atoms contract in the erbium-rich phases, and vice versa. (auth)

**22960** REINFORCEMENT OF MAGNESIUM WITH BORON AND TANTALUM FILAMENTS. Ahmad, I.; Barranco, J. M. (Benet Weapons Lab., Watervliet, NY). Met. Trans.; 4: No. 3, 793-797(Mar 1973).

Composites of magnesium reinforced with continuous boron filaments (0.004-in. dia and 450 ksi tensile strength), and tantalum (0.010-in. dia and 78 ksi tensile strength) were fabricated by the infiltration technique. The tensile strength of the boron filament dropped to nearly half its original strength (230 ksi) as a result of exposure to molten magnesium. The tantalum filaments, however, maintained their original strength after infiltration. The stress–strain curves of B–Mg composites were of a typical brittle material. The elongation in each case approached that of the filament, i.e., about 0.35%. Ta–Mg composites failed essentially in ductile manner. The elongation of the composites with 0.4 $V_f$ was as high as 15.7%. The elastic modulus, tensile and yield strength, and fracture behavior of the two composite systems are discussed. (auth)

**22961** PRECIPITATION WITHIN $\gamma'$ PARTICLES IN NICKEL-BASE SUPERALLOYS. Merrick, H. F. (International Nickel Co., Inc., Suffern, NY). Met. Trans.; 4: No. 3, 885-887(Mar 1973).

Annealing of IN-738 at 2050°F results in a coarse distribution of large $\gamma'$ particles (0.5 to 1 $\mu$ dia), and a second heat treatment at 1550°F causes the precipitation of smaller $\gamma'$ particles (0.1 to 0.15 $\mu$ dia). Replica and thin-foil transmission electron microscopy suggests that the fine precipitate within $\gamma'$ is not a carbide. A likely explanation is that these fine precipitations are simply the $\gamma$ phase. (DLC)

**22962** TEMPERATURE DEPENDENCE OF THE INTERNAL FRICTION IN Mo. Borisov, E. B.; Vedenyapin, G. A. Fiz.-Khim. Mekh. Mater.; 8: No. 5, 107-108(1972). (In Russian).

The internal friction, electrical resistance, and shear modulus of a technical grade of Mo were studied as functions of the temperature over the range 20 to 2100°C. The experimental data and calculations of the activation energy furnished additional information on the observed relaxation spectrum. (tr-auth)

**22963** CREEP OF SINGLE CRYSTALS OF MOLYBDENUM AT 0.57 OF THE MELTING POINT. Demchenko, L. V.; Dekhtyar, A. I.; Kozyrskii, G. Ya.; Kolesnikov, B. P.; Kononenko, V. A.; Epik, O. P. (Inst. of Metal Physics, Kiev). Metallofizika; No. 42, 47-55(1972). (In Russian).

The creep of single crystals of Mo of technical purity was studied in a vacuum at different orientations of the axes of the samples. At 1360°C and pressures from 0.8 to 1.2 kg/mm$^2$, deformation during creep was caused by slippage along certain planes; the activity and number of plane systems depended chiefly on the pressures in the possible slippage planes. Such deformation was not uniformly distributed and depended on the number of planes involved in slippage. (KSW)

**22964** STRUCTURAL CHANGES DURING HIGH-TEMPERATURE CREEP OF SINGLE CRYSTALS OF MOLYBDENUM. Demchenko, L. V.; Dekhtyar, A. I.; Kozyrskii, G. Ya.; Kolesnikov, B. P.; Kononenko, V. A.; Epik, O. P. (Inst. of Metal Physics, Kiev). Metallofizika; No. 42, 55-63(1972). (In Russian).

The kinetics of formation and changes in the substructure were studied during the process of creep of single crystals of Mo rectangular in cross section. Changes in the surface contour on the sample after creep at 1360°C were noted. The initial and successive planes involved in slippage were deduced from the observed traces of slippage. (KSW)

**22965** EFFECT OF PACKING DEFECTS ON FORMATION OF MARTENSITE PHASES. Lysak, L. I.; Goncharenko, I. B. (Inst. of Metalphysics, Kiev). Metallofizika; No. 41, 12-28(1972). (In Russian).

Quantitative study of packing defects in a fcc lattice was made according to diffraction data on single-crystal samples in the direction of a change in the angle of a change in the angle of reflection. It was established in single crystals of steel (0.7% C, 20.0% Re, and 0.5% C, 25.0% Re) that deformed packing defects were formed as a result of conversions of $\gamma$-, $\epsilon'$-, and $\epsilon$-phases in connection with densely packed planes. The converse lattices of $\epsilon'$- and $\epsilon$-martensites and their diffraction patterns were studied and compared with that of austenite in which chaotic deformation packing defects were present. (37 references) (tr-auth)

**22966** INFLUENCE OF CERIUM ON THE THERMAL STABILITY OF CAST IRON. Timoshenko, V. A.; Kalinin, V. T.; Krivosheev, V. A.; Fakhrutdinova, F. F. (Dnepropetrovsk Metallurgical Inst., USSR). Metallofizika; No. 41, 44-47(1972). (In Russian).

A comparative thermal stability study was made of the common grey and modified alloys of rare earth elements and cast iron at the three temperatures 650, 750, and 900°C by heating to the given temperature for 10 min and then chilling in water. The effects of this thermal treatment and other factors on the origin and growth of cracks in the cast iron were studied. Cast iron containing Ce (0.05 to 0.07%) and a compact form of graphite possessed a much greater stability than common cast iron with a flake form of graphite. (tr-auth)

**22967** X-RAY STUDIES OF POLYMORPHISM IN IRON ALLOYS. Dobrovol'skii, V. D.; Karal'nik, S. M.; Koval, A. V. (Kiev State Univ.). Metallofizika; No. 41, 68-73(1972). (In Russian).

The K absorption spectra were determined for Fe and its binary alloys with Ni, Cr, and V in connection with a change in their crystalline modifications. The typical composition tested contained Fe and one of the following (at. %): 45% Cr, 42% V, 20% Ni. Changes in the K spectrum were associated with changes in the crystalline structure and accompanying changes in the electronic structure of the atoms. The changes were treated as reflected redistribution on electrons in the periphery of atoms in the direction of consolidation of the latter on account of transition of the type sp → d (especially in $\alpha \rightarrow \gamma$ conversions), and to a certain extent by electrons in the outer periphery ($\alpha \rightarrow \sigma$). A qualitative interpretation of a number of known peculiarities may be derived. (tr-auth)

**22968** X-RAY STUDY OF SOME ALLOYS IN CONNECTION WITH DEVIATIONS FROM THE RULE OF ADDITIVITY. Dobrovol'skii, V. D.; Karal'nik, S. M.; Koval, A. B. (Kiev State Univ.). Metallofizika; No. 41, 73-77(1972). (In Russian).

X-ray absorption spectra of alloy components with Fe(Cr, V, Ni, Co) were studied, and deviations from the rule of additivity (Vegard's rule) were noted. Irregularities in the basic discontinuity of absorption were correlated with changes in the parameters of the alloy lattices, and were associated with changes in the electronic structure of the atoms. (tr-auth)

**22969** PHASE DIAGRAM AND SOME PROPERTIES OF NEODYMIUM–ANTIMONY ALLOYS. Kobzenko, G. F.; Chernogorenko, V. B.; Martynchuk, E. L.; Lynchak, K. A.; Skolozdra, R. V. (Inst. of Problems in Materials Studies, Kiev). Metallofizika; No. 41, 87-93(1972). (In Russian).

The phase composition diagram for the Nd–Sb system was constructed from data from thermal, metallographic, and x-ray analyses. The existence of four antimonides was confirmed: $Nd_5Sb_3$, $Nd_4Sb_3$, NdSb, and $NdSb_2$. The most refractory compound was NdSb, melting congruently at 2075°C. A correlation was made between the phase composition diagram and the time curves of "complete dissolution of a sample of the alloy." The antimonide NdSb was the least stable to corrosive attack. The methods of analysis included titration of Sb by $KMnO_4$, and Nd by Trilon B. (tr-auth)

**22970** PHASE DIAGRAM FOR THE Ta–Co SYSTEM. Pet'kov, V. V.; Kocherzhinskii, Yu. A.; Markiv, V. Ya. (Inst. of Metal Physics, Kiev). Metallofizika; No. 41, 93-97(1972). (In Russian).

The phase composition diagram of the system Ta–Co was investigated up to 50 at. % Ta using the methods of differential thermal, x-ray, and microstructural analyses. The five stable phases $\mu$, $\lambda_1$, $\lambda_2$, $\lambda_3$, and X were formed in the area studied, and had the following respective structural types: $W_6Fe_7$ (congruent), $MgZn_2$ (peritectoid and eutectoid) at 61.5% Co, $MgCu_2$ (congruent), $MgNi_2$ (peritectic), and X = an unknown structure (peritectoid) near 78% Co. In alloys containing ≥78 at. % Co, the presence of a metastable phase with the $Cu_3Au$ structure was noted. The compound $TaCo_3$ could not be found. (tr-auth)

**22971** ZONE PURIFICATION OF CHROMIUM ALLOYS WITH RARE EARTH METALS. Moish, Yu. V.; Pogrebnyak, V. I.; Rakitskii, A. I.; Pudoi, A. P.; Trefilov, V. I. (Inst. of Metal Physics, Kiev). Metallofizika; No. 41, 97-101(1972). (In Russian).

The influence of nonmetallic inclusions on the low-temperature ductility of Cr was studied, following refining with the aid of Pr and La. The purification of Cr + rare earth metals from nonmetallic inclusions effectively increased the low-temperature ductility of the material. The transition temperature may be lowered to –100°C by such purification, and the elongation and contraction of the transverse cross section were increased to 37 and 54%, respectively. (tr-auth)

**22972** REACTION OF THE METALLIDE $ZrCr_2$ WITH COMPOUNDS OF ZIRCONIUM WITH IRON, COBALT, AND NICKEL. Svechnikov, V. N.; Markiv, V. Ya.; Pet'kov, V. V. (Kiev State Univ.). Metallofizika; No. 42, 112-116(1972). (In Russian).

The systems $ZrCr_2-\{ZrFe_2, ZrCo_2, ZrNi_2\}$ were investigated by differential-thermal, x-ray, and microstructural analyses. Binary phase composition diagrams were constructed for the systems $ZrCr_2-ZrFe_2$ and $ZrCr_2-ZrCo_2$ from 900 to 1700°C; phase regions were established at 900°C in the system $ZrCr_2-ZrNi_2$. A third modification of the metallide $ZrCr_2$ with a structure of the $MgNi_2$ type was obtained, which had lattice periods a = 5.102 Å and c = 16.62 Å. (tr-auth)

**22973** REDKOZEMEL'NYE METALLY IN SPLAVY. (Rare Earth Metals and Alloys. Conference on Trends in Research and Application of Rare Earth Metals, Moscow, January 1969). Savitskii, E. M. (ed.). Moscow; Izdatel'stvo Nauka (1971). 127p. (CONF-690129-).

From Conference on trends in research and application of rare earth metals; Moscow, USSR (Jan 1969).

This book represents a collection of 42 papers by various authors which were delivered at the rare earth metal conference in 1969. Results of investigations on a wide range of properties of the rare earth metals are described, such as thermoemissive characteristics, surface activity, effects on the properties of V, Nb, Mo, and their alloys, and interactions of certain rare earths with each other. The applications of rare earth metals in ferrous and nonferrous metallurgy are described along with uses in petroleum and steel industries. The effects of rare earth elements on brasses, stainless steels, and other alloys are discussed. (KSW)

**22974** OUTLOOK FOR NIOBIUM. Rigaud; Bailon, J. P. Met. Constr. Mec.; 103: No. 12, 556-560; 566(Dec 1971). (In French).

The properties and uses of Nb, and its likely role in the future, are surveyed. (Metals Abstr.)

## *Radiation Effects*

*Refer also to abstracts 23799, 23802, 23803, and 23812.*

**22975** (CEA-CONF–2104) WORK OF THE IRRADIATION DAMAGE SUBGROUP OF THE EURATOM WORKING GROUP ON DOSIMETRY IN THE RESEARCH REACTOR. Genthon, J. P. (Commissariat A L'Energie Atomique, Saclay (France). Centre D'Etudes Nucleaires). 8 Sep 1972. 14p. (In French). (CONF-721074–2). Dep. NTIS (U. S. Sales Onlyp.

From Meeting of the dosimeter group of the International Agency for Atomic Energy; Seattle, Washington, USA (30 Oct 1972).

The Euratom Working Group on Reactor Dosimetry is working on problems of radiation-damage dosimetry. A paper was published (EUR-4867) giving recommendations on terms "fission flux" and "rapid flux", and about graphite, models, units, terms, numerical values, measured values, and measurement techniques. A second paper is ready, about metals; mainly steel. Other studies are in progress on measurement methods for dose relations with radiation damage. (auth)

**22976** (CEA-CONF–2105) MEASUREMENT OF THE IRRADIATION PARAMETERS OF PILE STRUCTURAL MATERIALS. Cance, M.; Genthon, J. P.; Labrousse, M.; Mas, P.; Salon, L. (Commissariat A L'Energie Atomique, Saclay (France). Centre D'Etudes Nucleaires). Sep 1972. 6p. (In French). (CONF-721074–1). Dep. NTIS (U. S. Sales Only).

From Meeting of the dosimeter group of the International Agency for Atomic Energy; Seattle, Washington, USA (30 Oct 1972).

Neutronic parameters for radiation-damage experiments are briefly reviewed; these include fluence, flux level (or irradiation duration), and temperature. The so-called G.A.M.I.N. graphite detector which measures "graphite flux" and $\Sigma$ spectrum indices (graphite/nickel) is described. The results of an international set of $\Sigma$ indices are summarized. (auth)

**22977** (COO-2206-1) VOID NUCLEATION AND GROWTH IN HEAVY-ION AND ELECTRON-BOMBARDED PURE METALS. PROGRESS REPORT, 1 MARCH-1 JUNE 1972. Kulcinski, G. L. (Wisconsin Univ., Madison. Dept. of Nuclear Engineering). 15 Jul 1972. Contract AT(11-1)-2206. 43p. Dep. NTIS $4.25.

**22978** (COO–2206-2) VOID NUCLEATION AND GROWTH IN HEAVY-ION AND ELECTRON-BOMBARDED PURE METALS. Progress Report, 1 June–15 September 1972. Kulcinski, G. L. (Wisconsin Univ., Madison. Dept. of Nuclear Engineering). 15 Oct 1972. Contract AT(11-1)-2206. 45p. Dep. NTIS $4.25.

The first 1-MeV electron-microscopy studies of high-purity Al were conducted. The studies were performed at WADCO because the UW EM-7 microscope acceptance tests were postponed to November 1972. Four samples were irradiated at $\sim 8 \times 10^{-4}$ displacements per atom (dpa) $sec^{-1}$ to 8.1 dpa at temperatures of 100, 150, 175 and 200°C. No voids (>30 Å) were observed under any of the above conditions. The microstructures consisted of a high density of faulted and unfaulted loops, and the density of such loops varied from $1 \times 10^{14}$ at 100°C to $<10^{12}$ at 175°C and no damage was observed after 200°C bombardment. A total of 49 Al samples were doped with 0.1, 1, and 10 at. ppM He for future $Al^+$ and electron-bombardment studies. These doping experiments delayed the operation of the heavy ion source by two months. The Physicon heavy ion source was bench tested and has produced 2 $\mu$A of Al ions at 15 kV. This is not the optimum amount of current because of different optics in the accelerator but such a beam is entirely adequate for the heavy-ion work. (auth)

**22979** (COO–2206-3) VOID NUCLEATION AND GROWTH IN HEAVY-ION AND ELECTRON-BOMBARDED PURE METALS. Progress Report, 1 March–1 November 1972. (Wisconsin Univ., Madison. Dept. of Nuclear Engineering). 25 Nov. 1972. Contract AT(11-1)-2206. 10p.. Dep. NTIS $3.00.

High-purity aluminum was irradiated in a 1-MeV transmission microscope at 100, 150, 175, and 200°C from 0 to 8.1 displacements per atom (dpa). The damage consisted of a large number of unfaulted, faulted, and doubly faulted loops after the 100 and 150°C irradiations. Very little damage was observed during the 175°C study and none during the 200°C test. No voids were observed at any of the above conditions. A 2-MV electrostatic generator was modified to accelerate heavy ions. A physicon heavy ion source was purchased, modified, bench tested, and installed in the accelerator. Thus far, a beam of 20 $\mu$A, principally $^{14}N$, has been extracted from the source. On this basis it is reasonable to expect 2 to 3 $\mu A/cm^2$ on the target which would correspond to displacement rates of 3 to $5 \times 10^{-3}$ $sec^{-1}$. Three sample chambers were built and operated at temperatures of 20 to 200, 20 to 700, and 20 to 1100°C. A total of 49 samples were doped with 0.1, 1 and 10 at. ppM He. A 2-MeV electron accelerator was modified to deliver a high current of finely focused electrons to samples on a specially designed sample chamber. Beam currents up to 500 $\mu A/cm^2$ were observed at 2 MeV. Such an electron flux produces a calculated damage rate of $7 \times 10^{-7}$ dpa per second. (auth)

**22980** (HEDL-SA-341) DIFFUSION MODEL FOR THE EFFECT OF APPLIED STRESS ON VOID AND LOOP GROWTH. Straalsund, J. L.; Guthrie, G. L.; Wolfer, W. (Hanford Engineering Development Lab., Richland, Wash.). 1972. Contract AT(45-1)-2170. 27p. (CONF-720672-1). Dep. NTIS.

From 75th annual meeting and exposition of the American Society for Testing and Materials; Los Angeles, California, USA (25 Jun 1972).

The effect of a general state of stress on swelling is considered in a theoretical void growth model. Angular-dependent loop growth is incorporated into the model in order to include the effects of shear stress. It is possible to consider stress-assisted void and loop growth as a relatively simple deformation process, which may be represented by the relation $\epsilon_i = \kappa(\sigma_i - \nu(\sigma_j + \sigma_k))$ where $\epsilon_i$ is the stress-induced increase in the strain rate in the $i^{th}$ principal direction. That is, $\epsilon_i = (d\epsilon_i/dt)_\sigma - (d\epsilon_i/dt)_{\sigma=0}$. $\kappa$ and $\nu$ depend upon microstructure (dislocation density, void number density and void size) but do not depend upon flux. The extent to which plastic flow must accompany stress assisted swelling is governed by the parameter $\nu$. As $\nu$ approaches $\frac{1}{2}$, the deformation process becomes pure shear. For $\nu = -1$, the deformation is purely dilatational (i.e., isotropic stress-assisted swelling). It is found that the value of $\nu$ is bounded and lies between $-\frac{1}{3}$ and $+\frac{1}{2}$. Thus, stress-assisted swelling cannot be completely shear-free. When transmission-electron-microscopy data for neutron-irradiated solution-treated

Type 316 stainless steel was used, the values of $\nu$ were found to lie between 0 and 0.5. For cold-worked steels, $\nu$ is expected to lie in the upper part of the range just given. The significance of the results becomes evident in the analysis of fuel-pin profiles. For isotropic swelling with no plastic flow, the fractional change in fuel-pin diameter is $\frac{1}{3}$ the fractional isotropic volume change. However, for stress-assisted swelling, the relation may be much different and depends upon the parameter $\nu$. For a pure biaxial stress state, for example, $\Delta D/D \approx 0.7\ \Delta V/V$ when $\nu = 0.1$, whereas $\Delta D/D \approx 1.4\ \Delta V/V$ when $\nu = 0.3$. (auth)

**22981** (HEDL-SA-387) FRACTURE AND TENSILE PROPERTIES OF IRRADIATED A533 PRESSURE VESSEL PLATE AND SUBMERGED-ARC WELD. Williams, J. A. (Hanford Engineering Development Lab., Richland, Wash.). 1972. Contract AT(45-1)-2170. 12p. (CONF-720468-1). Dep. NTIS.

From 6th annual information meeting on heavy section steel technology program; Oak Ridge, Tennessee, USA (25 Apr 1972).

The determination of the effects of irradiation on the fracture and strength properties of pressure vessel steel has been the primary objective of the Hanford Engineering Development Laboratory work in support of the HSST program. The material of interest is ASTM A533 Grade B Class I steel from HSST plate 02 and HSST weldment 51. Characterization of embrittlement by irradiation was evaluated by plane strain fracture toughness, $K_{Ic}$, measurements using one-inch thick compact tension (CT) specimens; tensile properties were studied in detail to determine the material sensitivity to the range of test temperatures and irradiation fluences of interest to reactor pressure vessel steel. (auth)

**22982** (HEDL-SA-497) IRRADIATION EFFECTS ON THE FRACTURE OF HEAVY SECTION PRESSURE VESSEL STEELS. Williams, J. A.; James, L. A. (Hanford Engineering Development Lab., Richland, Wash.). 23 Oct 1972. Contract AT(45-1)-2170. 18p. Dep. NTIS.

The fatigue-crack propagation behavior of A533-B steel was studied within the framework of linear-elastic frature mechanics. Tests were conducted at 75 and 550°F on unirradiated material and on material irradiated to 2.3 to $2.8 \times 10^{19}$ n/cm$^2$ and 5.3 to $5.7 \times 10^{19}$ n/cm$^2$ (E > 1 MeV). In general, at the cyclic frequency used (600 cpm), neither temperature nor neutron irradiation had a significant effect on the fatigue-crack propagation. Fracture properties were evaluated by plane strain ($K_{Ic}$) and lower bound equivalent energy ($K_{Icd}$) ($K_{Ic1}$ for thickness d = 1 in.) measurements for irradiated A533 weldment from the HAZ and fusion line and for A533 base plate material. The lower bound $K_{Ic1}$ of $2 \times 10^{19}$ n/cm$^2$ (E > 1 MeV) fusion line material was 175 ksi-in$^{1/2}$ at test temperature above 250°F; baseplate material, at similar irradiation and test conditions exhibited a $K_{Ic1}$ of approximately 190 ksi-in$^{1/2}$. Weldment material from the HAZ after irradiation to $0.5 \times 10^{19}$ tested to a value of 149 ksi-in$^{1/2}$ at room temperature, however, upper-shelf lower-bound toughness was not yet attained at that temperature. (auth)

**22983** (NRL-7526) CONTRIBUTIONS OF SELECTED RESIDUAL ELEMENTS TO THE RADIATION-EMBRITTLEMENT SENSITIVITY OF STEEL FORGINGS. Hawthorne, J. R. (Naval Research Lab., Washington, D. C.). 16 Nov 1972. Contract AT(49-5)-2110. 16p. Dep. NTIS $3.00.

Residual-impurity-element content has a major influence on the sensitivity of low-alloy steels to radiation-induced embrittlement. The identification of phosphorus as highly detrimental to irradiation performance has made tin, arsenic, and antimony additional suspect elements. The influence of tin, arsenic, and antimony on elevated-temperature radiation-embrittlement sensitivity was explored using a series of seven experimental NiCrMoV forgings. The forgings represented high and low phosphorus contents in addition to statistical variations of tin, arsenic, and antimony. Assessments of relative radiation sensitivity involved the exposure of Charpy-V specimens at 550°F to a neutron fluence of $3.1 \times 10^{19}$ n/cm$^2$ > 1 MeV. Postirradiation observations indicate that tin, arsenic, and antimony do not contribute directly to radiation-embrittlement sensitivity, either individually or in combination, for the composition range studied. In contrast, phosphorus (≈0.015%P) was observed to have a pronounced detrimental effect on radiation-embrittlement resistance. Of major significance, the contribution of phosphorus to radiation-embrittlement sensitivity was found greatly reduced by a high (100–150 ppM) tin content. The phosphorus-tin interaction appears to be independent of both antimony and molybdenum content for the levels investigated, but may be dependent on a high (≈150 ppM) arsenic content. Points of similarity and nonsimilarity in the influence of phosphorus and tin on radiation-embrittlement and temper-embrittlement behavior are described. (auth)

**22984** STUDY OF THE EFFECTS OF SAMPLE SIZE AND IRRADIATION OF THE HIGH-TEMPERATURE CREEP OF NICKEL – 6 WT. % TUNGSTEN. Matlock, D. K. Stanford, CA; Stanford Univ. (1972). 199p. University Microfilms Order No. 73-4551.

Thesis (Ph. D.).

The effects of both sample size and the presence of helium bubbles on the high-temperature (0.55 $T_m$ to 0.73 $T_m$) constant true-stress creep properties of a nickel-6 wt. % tungsten solid-solution alloy were studied in the stress range of 3000 psi to 7000 psi. In the first part of this investigation, constant true stress creep data on thin samples (0.007″ thick) were obtained. In these samples the average grain size was about one-half of the sheet thickness, and the grain size distribution was such that many of the grains traversed the thickness of the sheet. The steady-state strain rate data were analyzed to determine the activation energy for creep, $Q_{creep}$, and the stress dependence for creep as revealed in the stress exponent n. To explain the observed changes in creep properties with sample size, a model for creep deformation based on grain-boundary sliding and grain deformation was developed. For the second part of this investigation, helium was injected by alpha-particle irradiation into the thin Ni–6 wt % W creep samples to concentrations of 0.4 ppM and 4.0 ppM. It was determined that helium, in the form of helium bubbles on grain boundaries, greatly enhances high-temperature fracture. The observed fracture strains in the irradiated material were about 10% of the corresponding fracture strains for the unirradiated material. The effects of helium bubbles in intergranular fracture were examined with various microscopic techniques. Optical microscopy revealed that the predominant mode of fracture is by wedge-crack propagation due to grain-boundary sliding. Scanning electron fractographs show that fracture in the irradiated materials is of a brittle nature and that there are many voids associated with the fractured grain boundaries. Using these observations, models for the effects of helium bubbles on wedge-crack propagation are introduced and discussed. (JRD)

**22985** TENSILE PROPERTIES OF ANNEALED TYPE 316 STAINLESS STEEL AFTER EBR-II IRRADIATION. Fish, R. L.; Holmes, J. J. (Westinghouse Hanford Co., Richland, WA). Contract AT(45-1)-2170. J. Nucl. Mater.; 46: No. 2, 113-120(Mar 1973).

The effects of fast reactor neutron irradiation on the tensile properties of annealed Type 316 stainless steel were determined over a wide range of irradiation temperatures and reactor fluences. These effects are described as a function fluence and temperature to $7 \times 10^{22}$ n/cm$^2$ ($E_n$ > 0.1 MeV) at 430 to 820°C. The usual flow stress increase and ductility decrease were observed with increasing neutron fluence. Strengthening decreases continuously from 480°C to ≈700°C with no hardening at or above 760°C. Elongation values increase with temperature in the 430 to 540°C range and generally decrease with temperature above 540°C. (auth)

**22986** IN-REACTOR TUBULAR CREEP OF ZIRCALOY-2 AT 260 TO 300°C. Ibrahim, E. F. (Chalk River Nuclear Labs., Ont.). J. Nucl. Mater.; 46: No. 2, 169-182(Mar 1973).

Tubular specimens of Zircaloy-2, 23 mm in diameter, were in-reactor creep tested at 260 to 300°C. The specimens were biaxially stressed by internal pressure, with transverse stresses from 100 to 300 MN/m$^3$. Zircaloy-2 was tested in three conditions; 20% cold drawn, 70% tube reduced then stress-relieved, and annealed. All creep curves, both in and out of neutron fluxes, can be represented by straight lines on log strain–log time curves. Fast neutron flux increased the slopes of the log–log creep curves of the cold-worked materials. These slopes increased from 0.24 to 0.27 for unirradiated specimens (and specimens in the thermal neutron flux) to 0.42 to 0.47 for specimens in a fast-neutron flux. This means that creep rate does not diminish with time as rapidly in-reactor as out-reactor. The creep behavior of the annealed Zircaloy-2 was little affected by fast neutron flux. (auth)

**22987** GRAIN-BOUNDARY VISCOSITY IN NEUTRON-IRRADIATED ALUMINUM. Bose, S. K.; Mishra, R.; Bhattacharya, D. L. (Banaras Hindu Univ., India). Indian J. Pure Appl. Phys.; 10: No. 6, 468-470(Jun 1972).

Measurements of rigidity moduli were made on specpure aluminum wire specimens before and after neutron irradiation using a low-frequency torsion pendulum. From these data the coefficient of grain-boundary viscosity ($\eta$) was computed. It was found that $\eta$ is nearly ten times larger in neutron-irradiated specimens than in the annealed samples. This increase can be explained in terms of grain-boundary irradiation hardening. (auth)

**22988** PHYSICAL PHENOMENA IN THE INTERACTION OF AN ELECTRON BEAM WITH A SOLID. Burmakin, V. A.; Popov, V. K. Fiz. Khim. Obrab. Mater.; No. 6, 5-13(1972). (In Russian).

It was experimentally demonstrated that electron bombardment of the surface layer of a solid material produces a low-temperature, thermally unstable plasma with a high particle density. This plasma possesses excess positive charge and affects the technological aspects of electron beam treatment. (tr-auth)

**22989** ELECTRON IRRADIATION EFFECTS ON THE MECHANICAL PROPERTIES AND STRUCTURE OF ALUMINUM. Bondarenko, G. G.; Ivanov, L. I. Fiz. Khim. Obrab. Mater.; No. 6, 47-50(1972). (In Russian).

Samples of Al of various degrees of purity (99.9 and 99.99%) were irradiated with 2.3-MeV electrons at room temperature. The intensity of the beam was $10^{14}$ el/cm$^2$ · sec, and the integral dose was (2.5 to 7.2) × $10^{18}$ el/cm$^2$. Noticeable change in the 99.9% Al samples was observed in breaking tests; this change was associated with an accumulation of point defects which served effectively as blocking agents for the movement of dislocations. (tr-auth)

## Other Materials

*Refer also to abstracts 22844 and 22976.*

**22990** (BNL-17548) CONCRETE–POLYMER MATERIALS AND ITS WORLDWIDE DEVELOPMENT. Steinberg, M. (Brookhaven National Lab., Upton, N. Y.). Dec 1972. 14p. Dep. NTIS $3.00.

A wide range of concrete–polymer composite materials is under investigation in a number of laboratories around the world. For this materials development, the older technology of hydraulic cement concrete is combined with the newer technology of polymers to form new and improved materials of construction. Polymer impregnated precast concrete (PIC) is the more developed of the composites and exhibits the highest degree of strength and durability properties improvements. Polymer concrete (PC), an aggregate bound with polymer appears to be a promising material for cast-in-place applications. Numerous applications of PIC are presently under development which indicates a large potential for this material. (auth)

**22991** (BNWL-SA-4199) CONSTANT-STRESS IRRADIATION CREEP EXPERIMENTS ON GRAPHITE. Gray, W. J. (Battelle Pacific Northwest Labs., Richland, Wash.). 1972. 5p. (CONF-720609-8). Dep. NTIS $3.00.

From International carbon conference; Baden-Baden, Federal Republic of Germany (F. R. Germany) (26 Jun 1972).

Constant-stress irradiation-creep capsules were developed that permit application of a load to a stack of several graphite samples by a single pneumatic bellows. One tensile-creep capsule is operated at 800°C and two compressive-creep capsules operated at 550 and 800°C, respectively. Three types of graphite were irradiated under stresses up to 3000 psi. No tensile-creep data were available. Data for the compressive-creep experiments following the third irradiation period with total fluences up to about 1.0 × $10^{22}$ n/cm$^2$ (E > 0.18 MeV) indicate that, at 550°C, the creep was still essentially linear. At 800°C, however, the creep coefficient changed markedly at fluences above 6 × $10^{21}$ n/cm$^2$. For one graphite, the creep coefficient increased, while for the other two graphites, it decreased and even became negative in some cases. (auth)

**22992** (BNWL-SA-4200) EFFECT OF COLD-SEEDING ON IRRADIATION-INDUCED LENGTH CHANGES OF GRAPHITES. Gray, W. J. (Battelle Pacific Northwest Labs., Richland, Wash.). [nd]. 6p. (CONF-720609-9). Dep. NTIS $3.00.

From International carbon conference; Baden–Baden, Federal Republic of Germany (F. R. Germany) (26 Jun 1972).

Graphite samples were irradiated at temperatures between 50 and 500°C to fluences ranging from $10^{18}$ to $10^{20}$ n/cm$^2$ (E > 0.18 MeV) and then irradiated to high fluences at temperatures between 500 and 1300°C. Dimensional-change rates of these cold-seeded samples are compared with those of samples irradiated under identical conditions minus the brief irradiation at low temperatures. With only a couple of exceptions, cold-seeding under these conditions has no effect on those samples subsequently irradiated at 1000°C or above. However, cold-seeding does alter the dimensional-change rates for samples subsequently irradiated at 750°C by up to a factor of two. At that temperature, differences of about 50 percent were observed even when the fluence for the low temperature portion of the irradiation was as low as $10^{18}$ n/cm$^2$. (auth)

**22993** (LA–3514) CATHODIC VACUUM-ETCHING TECHNIQUES FOR GRAPHITE FUEL-ELEMENT SECTIONS. Bender, J. H. (Los Alamos Scientific Lab., N. Mex). 20 Apr 1966. Contract W-7405-eng-36. 16p. Dep. NTIS $3.00.

Declassified 19 Mar 1973.

Cathodic etching and polishing techniques have been developed that exhibit true graphite structures when using replication techniques applicable to electron microscopy. Rotary rough diamond and vibratory polishing with napless coverings and very short duration final polishing on napped cloth prevent extreme relief effects and "plucking" of soft particles in the graphite. Cathodic vacuum etching is accomplished by bombarding the specimen with Xe gas at an induced potential of 2.3 BV for 30 min at a chamber pressure of 2 μ with external 145-MHz rf excitation. Resultant graphite surfaces reveal true graphite flake structures and the retention of soft constituents in the binder. (auth)

**22994** (WRE-TM-694(WR and D)) MICROSCOPY STUDIES OF CARBON FIBRE AND ORGANIC PRECURSOR FILAMENTS. Hamshere, B. L. (Weapons Research Establishment, Salisbury (Australia)). Jul 1972. 20p. Dep. NTIS (U. S. Sales Only).

Optical and electron microscopy were employed to investigate the changes that occur when PAN precursor fibers are converted to carbon fibers by a heat treatment process consisting of oxidation, carbonization, and graphitization. In addition, an initial evaluation of the void and defect density in the precursor materials was made, and the effect of ion bombardment on the structure of carbon fibers was studied. (auth)

**22995** OXIDATION-RESISTANT MATERIAL. James, D. P. (to United States Borax and Chemical Corp.). British Patent 1,198,808. 6 Dec 1972. Filed date 17 Nov 1969. 4p.

A method is described for making a cheap high temperature oxidation-resistant material having high mechanical strength, such as is required for electric heating elements. The method comprises hot pressing a mixture containing 40 to 60% by weight of C (preferably graphite), 10 to 40% of Si, Ti disilicide, B silicide or Si carbide, or a mixture of two or more of these, and to 10 to 40% of B carbide, B silicide, Ti diboride, Zr diboride or B nitride, or a mixture of these; or the mixture may comprise simply C and B silicide. On exposure of the material so produced to the atmosphere a vitreous layer forms on the surface, which is believed to contribute to the oxidation resistance, the latter being outstanding at 600 to 1000°C. The material can be machined to give articles of various shapes, and is also suitable for safes and strong boxes. The pressing temperature may be 1 to 1.5 tons/sq in. and the temperature 1700 to 2200°C, and the mixture pressed to give a material of density at least 80% theoretical. Examples are given. (UK)

**22996** DIFFUSION OF URANIUM IN POLYETHYLENE DETERMINED BY FISSION-TRACK DETECTORS. Su, C. S. (National Tsing Hua Univ., Hsinchu, Taiwan). Nucl. Instrum. Methods; 107: No. 1, 29-31(15 Feb 1973).

The diffusion of uranium in polyethylene was studied by counting induced fission tracks of the diffused uranium atoms irradiated in a thermal reactor with thermal neutrons. Diffusions through 0.05 to 0.15 cm thickness of polyethylene sheets of temperatures from 87.5° to 110°C were investigated. The diffusion coefficient for each temperature was obtained from the slope of the logarithmic plot of the fission-track densities versus the square of the thickness of the diffusion medium. The temperature dependence of the diffusion coefficient in this temperature range was obtained as $D = 3.4 \exp(-15000/RT)$. (auth)

**22997** COATINGS TO IMPROVE WEAR RESISTANCE. Conte, A. A. Jr. (Naval Air Development Center, Warminster, PA). Mech. Eng.; 95: No. 1, 18-24(Jan 1973).

Coating materials designed to minimize adhesive and abrasive reactions between metal surfaces are described. Discussions and information are included on laminar solid coatings, plasma-deposited coatings, plastics, ceramics, and soft metals. Applications of coatings are reviewed. (JRD)

**22998** ABLATION OF ATJ GRAPHITE AT HIGH TEMPERATURES. Lundell, J. H.; Dickey, R. R. (Ames Research Center, Moffett Field, CA). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 11: No. 2, 216-222(Feb 1973).

Results of an extensive experimental program on the ablation of ATJ graphite in air at surface pressures of 0.3 to 4.4 atm and surface temperatures of 2570 to 4030°K are presented. The measured mass-loss rates are correlated with surface temperature, pressure, and effective nose radius. The results are compared with several equilibrium thermochemical ablation theories which differ basically in the chemical species that are considered and in the thermodynamic properties assigned to these species. All the theories predict about the same mass-loss rate in the diffusion-controlled oxidation regime and are in good agreement with the experimental results. At higher temperatures, however, the experimental and theoretical results do not agree. At temperatures above 3700°K, the experimental mass-loss rate becomes independent of pressure and an exponential function of temperature. A comparison of the high-temperature results with the theories indicates that all the theories, except the one based on the thermodynamic properties from the JANAF tables, are invalid because they overpredict the mass-loss rate. On the other hand, the theory based on the JANAF properties underpredicts the measured mass-loss rate by a factor of three at 4000°K. At least a portion of this difference between experiment and theory is attributed to particulate mass loss which is visually observed. 21 references. (auth)

**22999** EFFECT OF IRRADIATION ON THE MECHANICAL PROPERTIES OF ISOTROPIC PYROLYTIC CARBONS. Kaae, J. L. (Gulf General Atomic Co., San Diego, CA). J. Nucl. Mater.; 46: No. 2, 121-133(Mar 1973).

The effect of fast-neutron irradiation on the mechanical properties of a wide range of isotropic pyrolytic carbons deposited in a bed of fluidized particles was studied in three-point bending. For poorly crystalline isotropic carbons, large increases in the Young's modulus with increasing fast-neutron fluence were observed at irradiation temperatures below about 1200°C. At 1400 and 1600°C, increases in the modulus also occurred, but the increases were not as large as at the lower temperatures. Irradiation had little effect on the fracture stresses of these carbons. An as-deposited crystalline carbon irradiated along with the poorly crystalline carbons had smaller increases in the Young's modulus. The mechanical properties are discussed in terms of structural changes of the carbons during irradiation. (32 references) (auth)

**23000** HIGH-TEMPERATURE THERMAL ANALYSIS OF THE SYSTEMS $LaF_3-YF_3$, $SrF_2-YF_3$, and $MgF_2-YF_3$. Nafziger, R. H.; Lincoln, R. L.; Riazance, N. (Bureau of Mines, Albany, OR). J. Inorg. Nucl. Chem.; 35: No. 2, 421-426(Feb 1973).

Thermal-analysis experiments have established high-temperature phase relations in three systems containing $YF_3$ having potential use as fluxes for electroslag melting reactive metals. The $LaF_3-YF_3$ system is characterized by, (1) a eutectic occurring at 81 wt % $YF_3$ and approximately 400°C below the $LaF_3$ melting point, (2) a low-temperature hexagonal compound, (3) an extensive $LaF_3$ solid solution, and (4) limited $YF_3$ solid solution. A hexagonal compound with a range of composition, and whose x-ray lattice parameters increase with increasing $SrF_2$ content, is stable in equilibrium with liquid in the $SrF_2-YF_3$ system, resulting in the presence of two eutectics. A small liquidus-curve maximum occurs in the region where an extensive fluorite solid solution is the primary phase. No discernible solid solubility of $SrF_2$ in $YF_3$ was detected. The $MgF_2-YF_3$ system contains one eutectic with limited terminal solid solutions and a possible low-temperature compound. Due primarily to higher liquidus temperatures, systems containing $LaF_3$ possess a wider range of suitable electroslag fluxes than do systems containing $YF_3$. However, an optimum combination of high liquidus temperature and low electrical conductivity indicates selected compositions containing relatively low $YF_3$ in these systems may provide useful fluxes. Compounds present in systems containing $YF_3$ would probably not find uses in the electroslag process because of their relatively low stability temperatures. (auth)

**23001** RADIORESISTANT MATERIALS FOR THE NUCLEAR INDUSTRY. Gaussens, G.; Duchemin, J. (CEN de Saclay, Gif-sur-Yvette, France). Bull. Inform. Sci. Tech. (Paris); No. 171, 114-122(Jun 1972). (In French).

The effects of radiation on the chemical and mechanical properties of materials used in nuclear engineering are reviewed. Plastics and rubbers have a wide range of sensitivities to radiation. Chemical changes occurring as a result of irradiation include cross-linking, depolymerization, oxidative degradation and the formation of double bonds. Mechanical properties such as tensile strength, elastic moduli, hardness and flexibility are very strongly affected. A table of the radiation resistance of thermosetting, thermoplastic and elastomeric compounds is given. (FR)

# NUCLEAR MATERIALS AND WASTE MANAGEMENT

## Accountability and Safeguards

**23002** (BNWL-1682) ANALYSIS OF SHIPPER-RECEIVER DATA FOR PLUTONIUM NITRATE AND PLUTONIUM OXIDE. Stewart, K. B.; Wirfs, L. F. (Battelle Pacific Northwest Labs., Richland, Wash.). 15 Jan 1973. Contract AT(45-1)-1830. 83p. Dep. NTIS $5.45.

Two materials of high strategic value whose associated measurement errors play an important role in the accountancy of nuclear materials are plutonium nitrate and plutonium oxide. Because of the increasing importance of these materials to nuclear materials safeguards, a study was undertaken to assess recent (1969 to 1971) shipper–receiver measurement experience for these materials. Comparisons were made "between" and "within" data sets to explain discrepancies and to determine if the precisions shown by various measurers are significantly different. The results are presented simply as historical experience and no endeavor is made to draw technical conclusions as to whether the results represent the capability (best state of the art) measurement or even what might be judged good performance. (TFD)

**23003** (HEDL-TME-73-13) PLUTONIUM WASTE DRUM MONITOR. Jackson, C. N. Jr.; Goris, P. (Hanford Engineering Development Lab., Richland, Wash.). Jan 1973. Contract AT(45-1)-2170. 31p. Dep. NTIS $4.00.

A passive monitor provides unique capability for efficient, accurate monitoring of $PuO_2$ contained in waste drums up to 55 gallons in size. This monitor employs either gamma or neutron detectors for measuring $PuO_2$ content over a range from 0.010 to 150 grams. Four gamma detectors, each consisting of an integral assembly of a 3 × 3 inch NaI(Tl) crystal and a photomultiplier tube respond to the "384" KeV emission of $^{239}$Pu. A multi-channel analyzer provides a gamma count and a means of inspecting the gamma spectrum. The active detecting volume of gamma and neutron sensors extends the full height of the drum. A support table rotates the drum around its vertical axis at speeds up to 7 RPM to minimize errors due to non-uniform spacial distribution of Pu in a drum. Assay measurements for accountability purposes can be accomplished in 200 seconds with an estimated standard error of about 0.6% in the nuclear count at the one gram level. The report discusses technical aspects of the method and describes the electronic components, mechanical hardware, detectors, monitor sensitivity, the unique calibration standards and future areas for investigation. (auth)

**23004** (RFP-1900) EXCEPTION REPORTING OF NUCLEAR MATERIALS CONTROL. Doher, L. W.; Ferris, Y. M.; Rotherham, W. D. (Dow Chemical U.S.A., Golden, Colo. Rocky Flats Div.). [nd]. 11p. (CONF-720529-7). Dep. NTIS.

From 13th annual meeting of the Institute of Nuclear Materials Management; Boston, Massachusetts, USA (31 May 1972).

A new capability for reporting control of nuclear materials measurements is described. The needs for measurement control are reviewed, and Rocky Flats methods for assessing the uncertainties of measurements are outlined. Comparison follows of the reporting method in contrast to the current system. Advantages of exception reporting to nuclear materials managers are emphasized. Test statistics, capabilities, and advantages that are natural corollaries to exception reporting, and future plans are reported. (auth)

## Disposal and Storage

*Refer also to abstracts 22312 and 22477.*

**23005** (INIS-mf-276) MANAGEMENT OF RADIOACTIVE WASTES IN ITALY: PRESENT STATE AND FUTURE TRENDS. Branca, G. (Comitato Nazionale per L'Energia Nucleare, Casaccia (Italy). Centro Di Studi Nucleari). 1972. 14p. (In Italian). INIS.

The main sources of radioactive wastes existing in Italy are discussed. Information is given on the data concerning the amount of wastes produced until the year 1970. The treatment and disposal practices, generally followed in Italy, are briefly reviewed. Some considerations are presented on the most important phase in the management of radioactive wastes, that is, their ultimate disposal. In this view the wastes are classed into three basic categories: wastes that can be released to the environment; wastes requiring containment for hundreds of years; and wastes requiring containment for thousands of years. Possibilities and perspectives taking into consideration such types of ultimate disposal are briefly discussed. (INIS)

**23006** (INIS-mf-284) INTERNATIONAL CONTRIBUTION TO RADIOACTIVE WASTE MANAGEMENT. Williams, I. G. K. (European Nuclear Energy Agency, Paris (France)). 1972. 11p. INIS.

International control and cooperation in the development of radioactive waste management systems are discussed. (TFD)

**23007** CONTAINMENT SYSTEMS FOR STORAGE OF SOLIDIFIED HIGH-LEVEL RADIOACTIVE WASTES IN BEDDED SALT DEPOSITS. Sullivan, T. J. Ames, IA; Iowa State Univ. (1972). 156p. University Microfilms Order No. 73-3938.

Thesis (Ph. D.).

For long term storage of high-level radioactive wastes in bedded salt, it is necessary to minimize radionuclide migration and allow for a recovery operation. Containment systems were studied that provide continuous control of the waste, initially by metal or ceramic containers and finally by the reconsolidated salt formation. (TFD)

**23008** RADIOACTIVE WASTE MANAGEMENT AND CONSERVATION OF THE ENVIRONMENT. Burns, R. H. (Atomic Energy Research Establishment, Harwell, Eng.). At. Jap.; 16: No. 5, 59-80(May 1972).

Waste accumulation at power stations in the United Kingdom is controlled according to the Nuclear Installation Act, 1965. Disposal of waste, on the other hand, is controlled according to the Radioactive Substance Act, 1960, and it is applied when there is no intention to recover some material. Low-level liquid wastes arise from the purification processes for uranium and plutonium, washing of solvent used, control laboratories, equipment decontamination, and active laundry. In case of gaseous discharge to the atmosphere, no quantitative limit is specified, but it is required to regulate the discharge so that "public health is not endangered" and to use "best practicable means" to reduce such discharge. Solid radioactive wastes from authority establishments are buried at two sites in northern England or dumped at sea. Greatest restriction and difficulties have arisen in case of the discharge of liquid effluent to the river Thames. In 1951 the British Medical Research Council made specific recommendation for the maximum level permissible in the Thames which is based on the recommendation by International Commission on Radiological Protection at that time. Complete records must be kept regarding radioactivity discharged from the nuclear establishments in the United Kingdom, and results obtained by environmental monitoring are published annually. Careful planning, strict but sensible legislation, and adequate supervision and control if applied to all industrial waste-producing procedures would do much to minimize pollution of the environment. (JA)

**23009** DISPOSAL OF RADIOACTIVE GASES FROM NUCLEAR INSTALLATIONS. Richter, D.; Anders, G.; Schulze, H. Kernenergie; 15: No. 9, 293-302(Sep 1972). (In German).

In connection with the increasing use of nuclear energy the removal of radionuclides of iodine, xenon, and krypton from the off-gases of nuclear installations by retention, isolation, and storage is of great interest for reducing the release of radioactive materials into atmosphere and, consequently, for improving environmental protection. A review is given of problems concerning radioactive gaseous waste in nuclear installations, of the recent state of development of the possible techniques to isolate I, Xe, and Kr from gaseous wastes of nuclear power plants and reprocessing plants, and of disposal of radioactive gases into geological formations. From this the conclusion can be drawn that technological possibilities for a safe protection of environment in this field are given or may be developed in the future. (auth)

**23010** METHOD FOR THE DISPOSAL OF LIQUID RADIOACTIVE WASTE EFFLUENTS. Schoeneich, K. Przem. Chem.; 51: No. 11, 746(Nov 1972). (In Polish).

It is proposed to dispose of radioactive waste liquids by means of hydrofracturing of rocks using the method tried with success in the oil and natural gas industry to enhance the yield. It involves drilling a hole with a diameter of a few centimeters and a depth of about 1000 m, forcing the liquid into it under a pressure exceeding 160 atm. This causes vertical or horizontal cracks, depending on the position, of several tens of meter diameter in the impermeable rock. Cement is added to the waste liquids and the grout is allowed to solidify in the cavity, creating layers of impervious rock-like concrete. Cost estimate of the process is given. (TTT)

**23011** OPERATION "HOT MOLE." Donea, J. Euro-Spectra; 11: No. 4, 102-109(Dec 1972).

A rather unusual and elegant technique is proposed to solve the problem of storing high-activity radioactive effluents: self-burial, which consists of using the heat generated by radioactive decay to dump the waste in the deeper strata of the subsoil. A parametric study of the technique is presented, as well as the results of experimental verifications carried out on spherical and cylindrical model containers. (EU)

## Handling Equipment and Procedures

**23012** (GAT-DM-1136) RELATIVE EFFICACY OF VARIOUS MEANS OF ADDING NUCLEAR ABSORBERS TO DIRECT-STEAM-HEATED VAPORIZATION BAYS FOR 10-TON AND 14-TON UF$_6$ CYLINDERS. Feuerbacher, J. L. (Goodyear Atomic Corp., Piketon, Ohio). 28 Jul 1970. Contract AT(32-2)-1. 49p. Dep. NTIS.

Because of the difficulty and expense of indirect (dry) heating of 10-ton and 14-ton cylinders, particularly the excessive heating time required, and the very favorable history (with reference to UF$_6$ releases) of large cylinders in the direct-steam-heated bays, the GAT Nuclear Safety Committee decided to continue the use of these bays, with certain modifications recommended which were intended to improve nuclear safety. Among these modifications was the filling, to the extent possible, of the bottoms of the bays with glass raschig rings containing 4% boron. Since these rings are rather expensive, a computer study of a number of alternatives which appeared promising was made. The other methods included pipes of steel, copper, aluminum, polyvinyl chloride, and polyvinyl dichloride filled with borax or boric acid. Limited studies were made of the effects of pipe size, boron concentration, percent of the base volume occupied by the pipes, and the pipe arrangement in the bay. The nuclear effectiveness of each of the various cases is compared. (TFD)

**23013** (GAT-DM-1136(Add.1)) RELATIVE EFFICACY OF VARIOUS MEANS OF ADDING NUCLEAR ABSORBERS TO DIRECT STEAM-HEATED VAPORIZATION BAYS FOR 10-TON AND 14-TON UF$_6$ CYLINDERS, ADDENDUM NO. 1. Feuerbacher, J. L. (Goodyear Atomic Corp., Piketon, Ohio). 18 Nov 1970. Contract AT(32-2)-1. 15p. Dep. NTIS.

After the study reported in GAT-DM-1136 was completed, the suggestion was made that, because of the necessity of fairly-closely-spaced supports for chlorinated polyvinyl chloride (CPVC) pipe, an arrangement consisting of running the boric-acid-filled pipes crosswise in the bay bottom (that is, in the horizontal direction perpendicular to the cylinder's long axis) would be more practicable. For this reason, additional calculations were run, using $\frac{1}{2}''$ pipes in a crosswise orientation in an offset configuration, and also using a pipe composition which is more representative of the actual material contents of CPVC. The spacing is identical with that previously specified, within ordinary construction accuracy. In addition, the Nuclear Safety Committee requested that computations be run to investigate the relative efficacy of using short cut lengths of CPVC in a random configuration, without boric acid. For this test, in order to stay as near as possible to 24% of the base volume, 1" and $1\frac{1}{4}''$ Schedule 40 pipes were used, since they fall on either side of 24%. The computations were made with pipes running the length of the bay, as was done in simulating glass raschig rings. This should give conservative answers. Costs were also investigated. Use of pellets thrown into the bays, or of CPVC tape wrapped around steel pipes, was also investigated to the extent considered necessary. (auth)

**23014** (GAT-DM-1137) COMPUTER CHECK OF 2 1/2-TON UF$_6$ CYLINDERS AT 5% ASSAY IN DIRECT-STEAM-HEATED VAPORIZATION BAYS CONTAINING CHLORINATED POLYVINYL CHLORIDE PIPES FILLED WITH BORIC ACID. Feuerbacher, J. L. (Goodyear Atomic Corp., Piketon, Ohio). 17 Aug 1970. Contract AT(33-2)-1. 13p. Dep. NTIS.

A computer check was made on the multiplication factor of the vaporization bays for 10-ton and 14-ton UF$_6$ cylinders when loaded with $2\frac{1}{2}$-ton cylinders at a maximum assay of 5% $^{235}$U. The bays were assumed to be fitted, for the purpose of the calculations, with $\frac{1}{2}''$ polyvinyl chloride or chlorinated polyvinyl chloride pipes filled with boric acid over a range of bulk densities, the pipes occupying 24% of the volume of the base of the bay. The moderation of the uranium material in the bay bottom was in most cases assumed to be optimum. Any uranium material remaining in the cylinder was assumed to be at an H/$^{235}$U atomic ratio of 10.0. The cylinder wall thickness was taken to be $\frac{1}{2}''$. The cylinder was simulated (for the computer) by a steel parallelepiped with the same external horizontal dimensions as the bay. (In the 14-ton cylinder bays, the cylinder or parallelepiped would be empty, in the 10-ton cylinder bays nearly so.) (auth)

**23015** ADAC (ATELIER DE DECOUPAGE DES ASSEMBLAGES COMBUSTIBLES) WORKSHOP FOR CUTTING UP FUEL ASSEMBLIES. Mas, R. (CEA, Paris); Mercier, C. Bull. Inform. Sci. Tech. (Paris); No. 175, 5-17(Nov 1972). (In French).

This workshop at the Cadarache site possesses three $\alpha$ $\beta$ $\gamma$ cells. It is adjacent to the Rapsodie reactor and concerned with research and development in the field of fast neutron reactor fuels. Various types of examination are carried out (mostly nondestructive) to inspect the reactor fuel and the experimental assemblies after irradiation. The ADAC (Atelier de Decoupage des Assemblages Combustibles) serves as a relay post for the sorting and dispatch of fuel and structural parts to more specialized laboratories or chemical reprocessing plants. The large quantity of measurements undertaken led to the utilization of a computerized system for the acquisition, storage and processing of data. (FR)

**23016** METHODS FOR OBSERVING IRRADIATED FUELS AND STRUCTURES. Blanchard, P.; Gayet, B.; Huillery, R. (CEN de Cadarache, Saint-Paul-les-Durance, France). Bull. Inform. Sci. Tech. (Paris); No. 175, 19-37(Nov 1972). (In French).

The use of the periscope in the hot laboratory arises from the need to bring the object to be examined closer to the operator. The variety of objects involved has led to the utilization of a wide range of instruments. Some of these instruments are presented; a simple periscope with average specifications, a periscope with improved resolution and variable field, and apparatus with average field but very high resolving power and an apparatus enabling a very small zone, observed under a microscope, to be located in the sample. (FR)

## Transportation

**23017** (CONF-710847-, pp 215-226) PROBLEMS AND COSTS WITH SHIPMENT OF SPENT REACTOR FUEL. Johnson, S. F. (Aktiebolaget Atomenergi, Studsvik, Sweden). 1971. (In Swedish). From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

Transport regulations require effective radiation shielding, cooling, criticality safety, and ability to withstand even serious accidents. Present manufacturing costs for casks over 10 tons are around 6 to 8 Sw.Crs./kg for spent fuel from light-water reactors. These prices are likely to rise somewhat when shipments of the fuel from fast reactors become a reality because of the requirements for effective cooling and neutron shielding. Shipping costs, including insurance, for spent fuel are today between 25 to 50 Sw.Crs./kg U, which is about 25 to 35% of the total reprocessing costs. The total shipping costs can surely be reduced in the future by rational utilization of all shipping casks and by direct rail and sea communications between reactor and reprocessing plants. Sea connections are preferable. The distance plays a smaller role in terms of cost development. The shipment of spent reactor fuel calls for a comprehensive development study regarding construction and handling so that a reduction in the total costs can be made. (auth)

**23018** (TID-26288) ENGINEERING EVALUATION AND TEST REPORT OF PADUCAH TIGER FOR SHIPMENT OF ENRICHED UF$_6$ (10 TON CYLINDER). Hansen, L. J.; King, C. (Protective Packaging, Inc., Tacoma, Wash.). [nd]. 75p. Dep. NTIS $5.75.

The Paducah Tiger is a Type B overpack designed specifically for the shipment of UF$_6$ at a $^{235}$U assay greater than 1.1% contained within a standard 48A cylinder. Results of drop, puncture, and thermal tests to demonstrate compliance of the proposed Paducah Tiger in meeting all requirements of Federal Register Vol. 33, No. 194, dated Oct 4, 1968 are reported. The test program provided a finalized design that is conservative and capable of meeting or exceeding all applicable codes. (TFD)

**23019** (WASH-1238) ENVIRONMENT SURVEY OF TRANSPORTATION OF RADIOACTIVE MATERIALS TO AND FROM NUCLEAR POWER PLANTS. (Directorate of Regulatory Standards (AEC), Washington, D. C.). Dec 1972. 124p. Dep. NTIS.

A general analysis of the impact on the environment of transporting radioactive materials to and from a light-water nuclear reactor in accordance with the regulatory standards and requirements of the Atomic Energy Commission and the Department of Transportation is presented. (auth)

# PARTICLE ACCELERATORS

## Design, Development, and Operation

*Refer also to abstract 22651.*

**23020** (KFK-1720) STUDIES FOR A EUROPEAN SUPERCONDUCTING SYNCHROTRON. A GESSS Report. Heinz, W. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik). Dec 1972. 42p. Dep. NTIS (U. S. Sales Only) $4.25.

A group of three European laboratories (IEKP Karlsruhe, Germany; RHEL Chilton, England; and CEN Saclay, France) is studying the feasibility of pulsed superconducting magnets for use in high-energy synchrotrons, especially in the European 300-GeV proton synchrotron CERN, Geneva. The progress achieved in developing a pulsed superconducting magnet system including design considerations, conductor studies, magnets and cryogenic equipment is reported. Test results give confidence that most of the physical and engineering problems are reasonably well understood. The investigation concentrates now on fully engineered preprototype synchrotron magnets which cover most of the parameters for a full-scale prototype. (auth)

**23021** (LA-UR-73-267) PROPOSED ACCELERATOR FOR HEAVY IONS. Stokes, R. H. (Los Alamos Scientific Lab., N. Mex.). 1973. Contract W-7405-eng-36. 4p. (CONF-730310-10). Dep. NTIS.

From 5th Particle accelerator conference; San Francisco, California, USA (5 Mar 1973).

The design of a flexible linear accelerator for heavy ions is described. An array of short, independently phased helix resonators is used with a 4 MeV injector having a positive ion source. (auth)

**23022** (NAL-73/1) MONTHLY REPORT OF ACTIVITIES, DECEMBER 31, 1972. (National Accelerator Lab., Batavia, Ill.). 1972. Contract AT(49-8)-3000. 11p. Dep. NTIS.

Development and operating activities of the National Accelerator Laboratory for Dec., 1972 are summarized. Topics discussed include operating record, internal target section, neutrino section, 15-ft bubble chamber, proton section, and accelerator section. (TFD)

**23023** (NAL-73/2) MONTHLY REPORT OF ACTIVITIES, JANUARY 31, 1973. (National Accelerator Lab., Batavia, Ill.). 1973. Contract AT(49-8)-3000. 10p. Dep. NTIS $3.00.

Development and operating activities of the National Accelerator Laboratory during Jan. 1973 are summarized. Topics discussed include internal target section, neutrino section, 30-in. bubble chamber, 15-ft bubble chamber, meson section, and accelerator section. (TFD)

**23024** (NAL-76) MONTHLY REPORT OF ACTIVITIES, SEPTEMBER 30, 1972. (National Accelerator Lab., Batavia, Ill.). 1972. Contract AT(49-8)-3000. 8p. Dep. NTIS.

Development and operating activities of the National Accelerator Laboratory for Sept., 1972 are summarized. Topics discussed include meson section, neutrino section, internal target section, proton section, accelerator, 15-ft bubble chamber, and 15-ft bubble chamber piston failure. (TFD)

**23025** (NAL-79) MONTHLY REPORT OF ACTIVITIES, OCTOBER 31, 1972. (National Accelerator Lab., Batavia, Ill.). 1972. Contract AT(49-8)-3000. 9p. Dep. NTIS.

Development and operating activities of the National Accelerator Laboratory for Oct., 1972 are summarized. Topics discussed include six booster pulses accelerated to 200 GeV, operating record, internal target area, meson area, neutrino area, proton area, accelerator, and experiments. (TFD)

**23026** (NAL-82) MONTHLY REPORT OF ACTIVITIES, NOVEMBER 30, 1972. (National Accelerator Lab., Batavia, Ill.). 1972. (Contract AT(49-8)-3000. 5p. Dep. NTIS.

Development and operating activities of the National Accelerator Laboratory for Nov., 1972 are summarized. Topics discussed include operating record, internal target section, meson section, proton section, neutrino section, and accelerator. (TFD)

**23027** (NP-19688) ANNUAL REPORT, 1972. (Tri-Univ. Meson Facility, Vancouver (British Columbia)). Jan 1973. 67p. Dep. NTIS (U. S. Sales Only) $5.50.

Topics include the magnet, vacuum system, rf system, ion source and injection system, beam dynamics, probes and extraction, control system, safety, project management and schedule, engineering, buildings and services, shielding, and beam lines and experimental facilities. The initial experimental program is outlined, and a listing of the staff and a financial statement are given. Conferences, publications, and user groups are listed. (W.H.K.)

## Auxiliaries and Components

*Refer also to abstracts 22505 and 23334.*

**23028** (CONF-730310-1) RESONANT FREQUENCY CONTROL OF SUPERCONDUCTING RF CAVITIES. Peebles, P. Z. Jr. (Oak Ridge National Lab., Tenn.). [nd]. 18p. Dep. NTIS.

Resonant frequency of superconducting radio frequency (RF) cavities, which are used in linear accelerator research, may rapidly shift over many bandwidths because of vibration. An all electrical method is analyzed which can correct for these frequency shifts. The method depends upon the use of a voltage-variable reactance to control frequency. The general characteristics of control, such as the form and extent of frequency control and their dependence on design parameters, are first determined. Power distribution in the system is then found. (auth)

**23029** (IFVE-INZ-71-104) ADJUSTMENT OF ACCELERATING ELECTRODES IN THE ACCELERATOR WITH RF QUADRUPOLE FOCUSING. Zhuravlev, I. A.; Mal'tsev, A. P.; Sevost'yanov, V. S.; Stepanov, V. B.; Teplyakov, V. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukov. Institut Fiziki Vysokikh Energii). 1971. 6p. (In Russian). INIS.

A technique is described for the highly accurate assembly of accelerating electrodes in a linear proton accelerator with high-frequency quadrupole focusing. The electrodes were arranged on the axis of a resonator with the help of a special standard fastened by soldering. The accuracy of the mounting was 30 to 40 $\mu$. (tr-auth)

**23030** (KFK-1682) SUPPORT FOR ALIGNMENT OF BEAM TRANSPORT MAGNETS. Friesinger, G. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik). Dec 1972. 24p. (In German). Dep. NTIS (U. S. Sales Only) $3.25.

A support was designed and built for the adjustment of beam transport and synchrotron magnets (weight up to 10 Mp, maximum magnet length 4 m). The support presents the possibility for adjusting magnets in 6 degrees of freedom. The range of the adjustment is about ±15 mm. The resolution was measured to ±5 microns by the 3 translation degrees of freedom and to $\pm 5 \times 10^{-5}$ rad by the 3 rotation degrees of freedom. The upper part of the support is loaded by pneumatic equipment for magnets >4 Mp during adjustment. (auth)

**23031** (LA-UR-73-268) DESIGN AND MEASURED CHARACTERISTICS OF MINIMUM LOSS LOW-VELOCITY HELIX RESONATORS. Bendt, P. J.; Erkkila, B. H.; Stokes, R. H. (Los Alamos Scientific Lab., N. Mex.). 1973. Contract W-7405-eng-36. 3p. (CONF-730310-4). Dep. NTIS.

From 5th Particle accelerator conference; San Francisco, California, USA (5 Mar 1973).

The design and performance of helix resonators operating at room temperature are described. The resonators are analogous to $\lambda/2$ transmission lines shorted at both ends, and they oscillate at a frequency of 50 MHz. If slightly flattened 1/4 in. diam tubing is used to construct the helix, the resonators combine high shunt impedance with adequate coolant flow for high duty factor operation. Calculated and measured shunt impedances for different resonator phase velocities are given. The highest measured shunt impedance was 31 MΩ/m, for a resonator with a phase velocity equal to 0.04 c. For a steadily applied field of 1.25 MV/m, and a water pressure of 1500 psi, various helix designs have cooling water temperature rises of 10-22°C. Two coupling arrangements which provide 50 ohm resistive input impedance at resonance are described. The resonant frequency can be tuned by a threaded 3 in. diam copper plug mounted in the cylindrical wall. A facility for testing resonators at full power is described. (auth)

**23032** (UCRL-74287) APPLICATION OF CROSSBAR RELAYS TO THE CONTROL OF A BUNCHER RING. Gagnon, W.; Reginato, L. L.; Smith, B. H.; Lane, H. (California Univ., Livermore. Lawrence Livermore Lab.). 1 Feb 1973. 5p. (CONF-730310-2). Dep. NTIS $3.00.

From 5th Particle accelerator conference; San Francisco, California, USA (5 Mar 1973).

The high-current beam research at Livermore requires the capability of bunching the 700-A, 6-MeV electron beam of the Astron electron accelerator. The mass of the particles in the beam are modulated by an rf cavity and then transported around a 30-ft-diameter ring to produce bunching. The ring uses a set of eight bending magnets, a set of eight focusing magnets, and eight defocusing magnets. Each set of magnets is series connected and excited from a single power supply. To provide the necessary field trimming, a three-decade set of digitally actuated resistors is connected across each magnet. (auth)

**23033** (UCRL-74356) DEVICE FOR BUNCHING RELATIVISTIC ELECTRONS. Beal, J. W.; Copper, R. K.; Lamb, W. A.; Neil, V. K.; Prono, D. S.; Smith, L.; Wright, D. F. (California Univ., Livermore. Lawrence Livermore Lab.). 15 Feb 1973. 18p. (CONF-730310-3). Dep. NTIS $3.00.

From 5th Particle accelerator conference; San Francisco, California, USA (5 Mar 1973).

A device to bunch a longitudinally uniform beam of relativistic electrons has been designed, built, and operated successfully. The bunching results from a path length difference that is achieved by first modulating the energy of the beam particles and then passing the beam through a particular static magnet system. The buncher consists of an input beam transport employing solenoids, air-core quadrupole magnets, and n = 0 bending magnets followed by a strong focusing magnet ring arranged in an FDO configuration. Subsequent beam transport consisting of quadrupoles, bending magnets, and solenoids recombines the beam and transports it to the experimental area. Operationally, the results indicate that bunching ratios, $I_{peak}/I_{ave}$, of approximately two are rather routinely achieved with negligible beam loss. Single particle effects are consistent with the theory of simple phase-space dynamics. With regard to the all-important area of high intensity accelerator physics, observations have been made within the buncher system of coherent beam effects. Growth of very high frequency modulation has been measured for the unbunched, continuous beam. The growth appears to be intensity dependent; that is, the modulation grows faster with higher injected beam current. Qualitatively this beam behavior is consistent with well-established theory of coherent effects. (auth)

**23034** DESY ON-LINE SYSTEM. Akolk, F.; Dilcher, H.; Frese, H.; Hochweller, G.; Kuhlmann, P.; Raubold, E. (DESY, Hamburg, Ger.). Comput. Phys. Commun.; 4: No. 3, 275-278 (Dec 1972).

The DESY on-line system consists of 19 small computers which are connected on-line to IBM 360/75 and IBM 360/65 computers. The small computers (16k words memory, 12 bits per word) are used for the following purposes: (1) data-gathering from high-energy physics experiments; (2) transfer of experimental raw data to IBM 360; (3) receiving control information from the IBM 360 for the proper running of the experiments; (4) Permanent check of the experimental setup. Detailed discriptions of software and hardware are given. (auth)

## Ion Optics and Field Calculations

*Refer also to abstract 23441.*

**23035** (CERN-73-1) NUMERICAL COMPUTATION OF FIELD DISTRIBUTION AND FREQUENCY IN THE LOWER PASSBANDS OF A SYMMETRICAL PERIODIC STRUCTURE. Part I. Theory. Bell, M.; Dome, G. (European Organization for Nuclear Research, Geneva (Switzerland)). 16 Jan. 1973. 134p. Dep. NTIS (U. S. Sales Only).

In the past, relaxation methods have been used to compute the electromagnetic fields and the frequency of a periodic structure having a symmetry plane and rotational symmetry about its axis, at modes which are multiples of $\pi$. These computations involve determining one scalar function over a half-cell of the structure. It is shown that by determining two scalar functions over a half-cell of the structure, it is possible to compute by relaxation methods the electromagnetic fields and the frequency at any mode in the lower passbands of a symmetrical periodic structure, for a traveling wave as well as for a standing wave. All quantities of interest: shunt impedance, transit time factor, quality factor Q, group velocity, may then be computed with good accuracy for any operating mode of the structure. A description is given of computer programs which have been written for an Alvarez linac cell without stem, but which apply as well to any loss-less periodic structure having a symmetry plane and rotational symmetry around its axis. The theoretical basis of the computation is presented and numerical results are given. (auth)

**23036** (IFVE-SKU-71-72) HIGH INTENSITY ACCELERATOR BEAM-CAVITY RESONATOR INTERACTIONS AT TRANSITION. Balbekov, V. I.; Pashkov, P. T. (Gosudarstvennyi Komitet Po Ispol'Zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1971. 17p. (In Russian). INIS.

The process of intersection of critical energy in a proton synchrotron with an intense beam was examined. Not only the longitudinal Coulomb field of clusters, but also the potential, being produced by them at resonators in accelerating stages are evaluated. These effects may make a contribution to the modulation of the enveloping clusters, which arises after the intersection of critical energy. The results which were processed by computer are presented in the form of graphs which encompass a wide range of parameters of the accelerator. (tr-auth)

**23037** (JINR-P9-6921) NOTE ABOUT THE MOVING RELATIVISTIC RING $H_\varphi$-FOCUSING. Bonch-Osmolovsky, A. G. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1971. 10p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

The equilibrium (focusing) conditions for a charged ring moving with relativistic velocity along the axis of a spiral magnetic field are defined more accurately. It is shown that focusing is possible at moderate values of the azimuthal component of a magnetic field and particle number in a ring up to $10^{15}$. (auth)

**23038** (NP-19689) SOME EFFECTS OF BEAM SPACE CHARGE IN SUPERCONDUCTING CYCLIC ACCELERATORS AND STORAGE RINGS. Preprint B-0166. Deryugin, G. M.; Mingalev, B. S.; Shukeilo, I. A. (Scientific Research Inst. of Electrophysical Apparatus, Leningrad (USSR)). 1972. 14p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

The incoherent shift of betatron frequency in an intense beam of elliptic cross section is calculated taking into account the proximity to structural elements of an accelerator with a superconducting magnet. It turns out that the ultimate intensity is greater by an order of magnitude than that in classical accelerators. The influence of accelerator construction elements surrounding the beam, upon the shape of a closed orbit whose position does not coincide with the axis of the vacuum chamber is considered quantitatively. (auth)

**23039** (UCRL-74288) PROBLEM OF COUPLING A 120-MHz RF CAVITY TO A 700-A, 6-MeV PULSED ELECTRON BEAM. Cooper, R. K.; Neil, V. K.; Reginato, L. L.; Smith, B. H. (California Univ., Livermore. Lawrence Livermore Lab.). [nd]. 4p. (CONF-730310-6). Dep. NTIS.

From 5th Particle accelerator conference; San Francisco, California, USA (5 Mar 1973).

A 120-MHz cavity and rf system were built to modulate the beam energy of the Astron electron accelerator by ±5%. The beam pulse has a rise time of 20 ns which initiates a transient in the cavity. The cavity was designed to limit the transient voltage in order to avoid sparking. The excitation problem was studied both experimentally and theoretically. Design criteria were established that allowed coupling of an rf cavity to a high-current beam as easily as to the low-current beams of the usual research accelerators. (auth)

**23040** TWO-DIMENSIONAL COMPUTER SIMULATION OF HIGH INTENSITY PROTON BEAMS. Lapostolle, P.; Le Bail, R. (CERN, Geneva). Comput. Phys. Commun.; 4: No. 3, 333-338 (Dec 1972).

A computer program has been developed which simulates the two-dimensional transverse behavior of a proton beam in a focusing channel. The model is represented by an assembly of a few thousand "superparticles" acted upon by their own self-consistent electric field and an external focusing force. The evolution of the system is computed stepwise in time by successively solving Poisson's equation and Newton's law of motion. Fast Fourier transform techniques are used for speed in the solution of Poisson's equation, while extensive area weighting is utilized for the accurate evaluation of electric field components. A computer experiment has been performed on the CERN CDC 6600 computer to study the nonlinear behavior of an intense beam in phase space, showing under certain circumstances a filamentation due to space charge and an apparent emittance growth. The results obtained led to a generalization in a nonlinear region of the "beam envelope oscillations" so far developed only for uniform density distributions; many cross checks have been made between the new theory and numerical results, including total energy and other integral expressions. This is now leading to a progressive understanding of space-charge phenomena of stochastic type. Some results are displayed on a motion picture. (auth)

## Storage Rings

**23041** INTERFERENCE OF SYNCHROTRON RADIATION PHOTONS FROM A SINGLE ELECTRON. Grishaev, I. A.; Guk, I. S.; Mazmanishvili, A. S.; Tarasenko, A. S. (Physical Technical Inst., Kharkov). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1645-1648 (Nov 1972). (In Russian).

An interference experiment with statistically independent synchrotron radiation photons from a single electron in the storage ring is performed. It is shown that when the intensity is such that simultaneous presence of two photons in the interferometer is practically excluded, the radiation from one or more electrons produced a radiation pattern which qualitatively does not depend on the number of emitters. The results of the experiments are a convincing proof of the validity of the quantum mechanical supperposition principle at super-low radiation fluxes. (auth)

## Experimental Facilities

*Refer also to abstracts 22545 and 22546.*

**23042** (IFVE-SEF-71-66) LARGE LIQUID-HYDROGEN-DEUTERIUM TARGET OF A STABILIZED DENSITY. Vasil'ev, L. M.; Dmitrevskii, Yu. P.; Mel'nik, Yu. M.; Sytnik, V. V. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1971. 18p. (In Russian). INIS.

A three-meter liquid hydrogen–deuterium target with a stabilized density is described which was used in experiments on particle beams from an accelerator. A thermal shield of working liquid produced waste vapors. The average quantity of hydrogen along the target axis was 21.15 g/cm$^2$. The density stability of the hydrogen in the operating part was $\sim$0.05%. The total volume of the target was 205 liters. Operating time without replenishment was 200 hours. (tr-auth)

**23043** (KFK-1684) HELIUM-BATH IRRADIATION FACILITY FOR SUPERCONDUCTING MATERIALS WITH 25 MeV PROTONS, 50 MeV DEUTERONS, OR 100 MeV $\alpha$-PARTICLES. Becker, H.; Katheder, H. K.; Seibt, E.; Steinacker, S. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik). Dec 1972. 43p. (In German). Dep. NTIS (U. S. Sales Only) $4.25.

An experimental facility for helium-bath irradiation at the Karlsruhe isochronous cyclotron was built. Superconductors and other materials can be irradiated in liquid helium at 4.2°K with 25 MeV protons, 50 MeV deuterons or 100 MeV $\alpha$-particles. To study the nuclear irradiation influence on the superconductor properties, the specimens can be measured at 4.2°K in the same bath. The particle beams can be focused at the position of the specimen to a beam spot area of 3 to 10 mm in diameter. Irradiation dose and He-loss measurements with NbTi multicore conductors have been performed. The apparatus ran some tests with up to 2 $\mu$A deuteron and 1.5 $\mu$A $\alpha$-particle current. For 100 MeV $\alpha$-particle irradiation the liquid helium losses come to (55 ± 6) 1/$\mu$Ah. The temperature rise in the beam spot center of the irradiated specimen can be recorded by a calibrated temperature measurement system. (auth)

**23044** (LA-UR-73-231) DENSITY PROFILES OF A SUPERSONIC JET TARGET. Brolley, J. E. (Los Alamos Scientific Lab., N. Mex.). 1972. Contract W-7405-eng-36. 3p. (CONF-730310-5). Dep. NTIS.

From 5th Particle accelerator conference; San Francisco, California, USA (5 Mar 1973).

A supersonic jet target of $H_2(D_2)$ having an areal density of $5 \times 10^7$ protons/cm$^2$ and 360° access in vacuum has been fabricated for use on the LAMPF NPL beam. (auth)

**23045** (LA-UR-73-320) MECHANICAL DESIGN OF THE LAMPF LOW ENERGY PION CHANNEL. Fulton, R. L. (Los Alamos Scientific Lab., N. Mex.). 1972. Contract W-7405-eng-36. 2p. (CONF-730310-8). Dep. NTIS.

From 5th Particle accelerator conference; San Francisco, California, USA (5 Mar 1973).

A pion channel has been designed and nearly completed that will provide a good quality, high intensity pion beam of energies up to 300 MeV. Important channel features are a vertical bend plane, close alignment tolerances, short channel length, and remote handling near the production target. These features influenced the mechanical design of the magnets, support and alignment, collimation system, vacuum system, and shielding. (auth)

**23046** GAS JET TRANSPORT SYSTEM FOR THE RADIOACTIVE PRODUCTS OF FAST-NEUTRON INDUCED FISSION. Dautet, H.; Gujrathi, S.; Wiesehahn, W. J.; D'Auria, J. M.; Pate, B. D. (Simon Fraser Univ., Burnaby, British Columbia). Nucl. Instrum. Methods; 107: No. 1, 49-59(15 Feb 1973).

A gas jet transport system has been developed for the recoil products of fission induced by 14.0-MeV neutrons. Fission products having half-lives of the order of seconds have been transported a distance of 30 m from the point of production. An overall collection efficiency of about 70% was achieved using ethylene as the carrier gas or in mixtures with either He or $N_2$. Gamma and x-ray spectra of the radiations emitted by the fission products, resulting from the reaction of 14.0-MeV neutrons with a thin natural uranium foil, were obtained. Calculations on the nature of the flow of the gas in the capillary are included. (auth)

# PHYSICS (ASTROPHYSICS AND COSMOLOGY)

## Cosmic Radiation

*Refer also to abstracts 22549 and 23339.*

**23047** (FRNC-TH-204) EXPERIMENTAL DETERMINATION OF THE CHEMICAL COMPOSITION OF COSMIC RADIATION IN THE $10^{15}$ TO $10^{17}$ eV INTERVAL FROM STUDIES OF THE ANGULAR DISTRIBUTIONS OF EXTENSIVE AIR SHOWERS. Catz, P. (Paris Univ. (France)). 1970. 117p. (In French). INIS. Thesis.

After having briefly reviewed the principal characteristics of extensive electromagnetic air showers, the principal results obtained from such studies are presented. It was demonstrated that the electromagnetic shower model does not correspond to the real situation, and that it is necessary to envisage the existence of a nuclear cascade initiated by protons and nuclei. A detailed description is given of the experimental equipment developed for this study. The principles of the original method used to study the chemical composition of these showers are presented. The experimental results are compared with those previously obtained and with the theoretical predictions of the Durham group made using a very realistic model. (FR)

**23048** (NP-19678) COSMIC RAY RECORDS, MAWSON, 1969. Anare Data Reports Publication No. 115. Cooper, G.; Vrana, A. (Department of Supply, Melbourne (Australia). Antarctic Div). 1971. 113p. Dep. NTIS (U. S. Sales Only) $7.75.

Tables for the following Antarctic data measurements are given: 1) hourly data from the vertical telescope; 2) data from the wide-angle inclined telescope from geomagnetic east and west azimuth readings; 3) data from the high zenith angle telescope for geographic north and south azimuth readings; 4) uncorrected hourly data from the neutron monitor; 5) data from the neutron monitor, corrected for barometric pressure variations; 6) hourly mean station level pressure; and 7) upper air data from all radiosonde flights conducted from the station. (AU)

**23049** (NP-19679) COSMIC RAY RECORDS, MAWSON, 1970. Anare Data Reports Publication No. 119. Parer, D.; Cooper, G. (Department of Supply, Melbourne (Australia). Antarctic Div). 1971. 113p. Dep. NTIS (U. S. Sales Only) $7.75.

Tables for the following Antarctic data measurements are given: 1) hourly data from the vertical telescope; 2) data from the wide-angle inclined telescope from geomagnetic east and west azimuth readings; 3) data from the high zenith angle telescope for geographic north and south azimuth readings; 4) uncorrected hourly data from the neutron monitor; 5) data from the neutron monitor, corrected for barometric pressure variations; 6) hourly mean station level pressure; and 7) upper air data from all radiosonde flights conducted from the station. (AU)

**23050** (NP-19680) COSMIC RAY RECORDS, CASEY, 1969. Anare Data Reports Publication No. 117. Johnstone, P.; Bilson, J. R. (Department of Supply, Melbourne (Australia). Antarctic Div). 1972. 44p. Dep. NTIS (U. S. Sales Only) $4.25.

Tables for the following antarctic data measurements are given: 1) uncorrected neutron monitor data obtained at Wilkes, Jan to Apr 1969, and at Casey, Apr to Dec 1969; 2) neutron monitor data, corrected for barometric pressure variations, obtained at Wilkes, Jan to Apr 1969, and Casey, Apr to Dec 1969; 3) mean hourly station level pressure in units of 0.1 mbar measured from a zero level of 940 mbar obtained at Wilkes, Jan to Apr, and Casey, Apr to Dec, 1969. (AU)

**23051** INVESTIGATION OF SLOW NEUTRONS IN THE LOWER LAYERS OF THE ATMOSPHERE. Abdurakhmanov, A. Kh.; Efimov, Yu. E.; Romanov, A. M.; Chichikalyuk, Yu. A. (Ioffe Inst. of Physics and Tech., Leningrad). Geomagn. Aeron. (USSR) (Engl. Transl.); 12: No. 3, 475-476(1972).

Translated from Geomagn. Aeron.; 12: No. 3, 537(1972).

The performance of two identical proportional counters to determine the density of atmospheric neutrons at the counter site is described. The measurements were made in August 1969 from a point with a geomagnetic latitude $\phi = 57°$N. Geomagnetic activity was low during the measurement period. The results are compared with measurements made in March 1965, a minimum solar-activity epoch. (JCW)

**23052** HARD ROCK COSMIC RAY ARCHAEOLOGY. Lal, D. (Tata Inst. of Fundamental Research, Bombay). Space Sci. Rev.; 14: No. 1, 3-102(Dec 1972).

Recent examinations of extraterrestrial materials exposed to cosmic rays for different intervals of time during the geological history of the solar system have generated a wealth of new information on the history of cosmic radiation. This information relates to the temporal variations in (i) the flux and energy spectrum of low energy (solar) protons of $\geq 10$ MeV kinetic energy; (ii) the flux and energy spectrum of (solar) heavy nuclei of $Z > 20$ of kinetic energy, 0.5-10 MeV/n; (iii) the integrated flux of protons and heavier nuclei of $\geq 0.5$ GeV kinetic energy, and (iv) the flux and energy spectrum of nuclei of $Z > 20$ of medium energy—100 to 2000 MeV/n kinetic energy. The above studies are entirely based on the natural detector method which utilizes two principal cosmogenic effects observed in rocks, (i) isotopic changes and (ii) changes in the crystalline structure of rock constituents, due to cosmogenic interactions. The information available to date in the field of hard rock cosmic-ray archaeology refers to meteorites and lunar rocks/soil. Additional information based on study of cosmogenic effects in man-made materials exposed to cosmic radiation in space is also discussed. It is shown that the natural detectors in spite of their extreme simplicity have begun to provide cosmic-ray information in a very quantitative and precise manner comparable to the most sophisticated electronic particle detectors. The single handicap in using the hard rock detectors is however the uncertainty regarding their manner of exposure, geometry etc. At present, a variety of techniques are being used to study the evolutionary history of extraterrestrial materials and as this field grows, uncertainties in cosmic-ray archaeology will correspondingly decrease. (auth)

**23053** PRIMARIES OF EXTENSIVE AIR SHOWERS OF COSMIC RADIATION. Sreekantan, B. V. (Tata Inst. of Fundamental Research, Bombay). Space Sci. Rev.; 14: No. 1, 103-174 (Dec 1972).

The various types of interactions between the microwave photons and the high-energy hadrons and photons in the primary cosmic radiation are summarized and the consequences of these interactions on the primary spectrum, composition, and directional distribution are pointed out. The implications of the discovery of pulsars, the mechanisms proposed for acceleration of particles to cosmic-ray energies, and the consequences on the directional distribution and the need for a systematic search for point sources of gamma rays are briefly discussed. A general outline of the method of EAS that has been developed to elicit the properties of primary cosmic rays is presented and the dependence of the interpretation of the results on various types of fluctuations, changes in the characteristics of collisions, etc. is discussed. The various results on the primary spectrum from $10^{10}$ to $10^{21}$ eV are presented. In the energy range $10^{10}$ to $10^{15}$ eV the results from direct investigation with calorimeters carried out on satellites and balloons are described. From $10^{14}$ to $10^{21}$ eV the primary spectrum is derived entirely on the basis of air shower studies. The present status concerning the primary composition in the various energy bands and the methods that have been used to arrive at these results are described. The arrival direction distributions of the primaries of air showers of various energies are discussed. The efforts to search for primary gamma rays both as diffuse background and as discrete sources are described and the results summarized. The present status concerning the characteristics of high energy interactions at various energies as derived from cosmic-ray investigations at mountain, balloon, and satellite altitudes and from the study of extensive air showers is discussed with particular emphasis on the effects that the characteristics have on the interpretation of air shower data, especially regarding the derivation of the characteristics of primary cosmic rays. The results on the primary cosmic rays at the high energy end are summarized and an attempt is made to examine the results critically from the point of view of discerning the lines on which future investigations need to be carried out both from the astrophysical and nuclear physical aspects of ultra high-energy cosmic-ray research. (WDM)

**23054** COSMIC RAY INVESTIGATION OF THE PROTON-PROTON CROSS SECTION IN THE ENERGY RANGE $2 \times 10^{12}$-$5 \times 10^{13}$ eV. Wdowczyk, J.; Zujewska, E. (Inst. of Nuclear Research, Lodz, Poland). J. Phys., A (London); 6: No. 2, L9-L11(Feb 1973).

Experimental results on the intensity of surviving cosmic-ray protons at an atmospheric depth of 550 g $\mathrm{cm^{-2}}$ by Murakarmi et al. (1970) have been used together with measurements of the primary spectrum to show that there is no evidence to suggest a change in the magnitude of the inelastic proton-proton cross section up to $5 \times 10^{13}$ eV. (auth)

**23055** CONSEQUENCES OF A UNIVERSAL COSMIC-RAY THEORY FOR $\gamma$ RAY ASTRONOMY. Strong, A. W. (Univ. of Durham, Eng.); Wolfendale, A. W.; Wdowczyk, J. Nature (London); 241: No. 5385, 109-110(12 Jan 1973).

It is pointed out that in spite of the considerable advances in knowledge concerning energetic extra-terrestrial objects in recent years, no satisfactory explanation has appeared regarding the origin of cosmic rays; it is not clear even whether the important sources are within or outside the Galaxy. The possibility is considered here of reviving a theory due to Hillas (Can. J. Phys. 46: S.623 (1968)) in which the observed shape of the primary spectrum up to about $3 \times 10^{19}$ eV is explained in terms of an evolving sources model with constant spectral index at production, and interactions with the microwave background radiation. Such a model could explain the sharp change of slope at $3 \times 10^{15}$ eV inferred from measurements of the sizes of extensive air showers, as well as the high degree of isotropy that is maintained up to at least $10^{19}$ eV. Objections to such a theory are discussed, and the possibility of their removal. Calculations are made for a model in which the energetic cosmic rays are protons, including the proton spectrum expected at the present epoch after the protons have interacted with the microwave background. The expected $\gamma$-ray spectrum is shown. Also shown are the experimental measurements of the diffuse $\gamma$ background from satellite and balloon experiments. It is finally concluded that what appeared to be a very attractive model is untenable. (UK)

**23056** SPALLATION PRODUCTION OF $^3$He, $^{21}$Ne, AND $^{38}$Ar FROM TARGET ELEMENTS IN THE BRUDERHEIM CHONDRITE. Bogard, D. D.; Cressy, P. J. (Manned Spacecraft Center, Houston, TX). Geochim. Cosmochim. Acta; 37: No. 3, 527-546 (Mar 1973).

The concentrations of noble gas isotopes of He, Ne, and Ar have been measured in eight mineral separates of the Bruderheim chondrite. The cosmic-ray-produced nuclides $^{21}$Ne and $^{38}$Ar were correlated by a computer least-squares fitting program with the elemental composition in each separate of potential targets for nuclear production yielding the following production equations: $[^{21}\text{Ne}, 10^{-8}\ \text{cm}^3/\text{g}] = k(0.45[\text{Mg}] + 0.085[\text{Si}] + 0.060[\text{S}] + 0.017[\text{Ca}] + 0.0044[\text{Fe} + \text{Ni}])$; $[^{38}\text{Ar}, 10^{-8}\ \text{cm}^3/\text{g}] = k(2.6[\text{K}] + 0.37[\text{Ca}] + 0.08[\text{Ti} + \text{Cr} + \text{Mn}] + 0.021[\text{Fe} + \text{Ni}])$ with elemental concentrations in weight per cent and k equal to the reciprocal of the cosmic-ray exposure age of Bruderheim. The P(S)/P(Cr + Mn + Fe + Ni) weight production ratio for $^3$He was determined to be 1.53; relative productions of $^3$He from O, Mg, and Si and $^{21}$Ne from Al proved to be incalculable. (auth)

**23057** CERTAIN PECULIARITIES IN THE DISTRIBUTION OF MERCURY IN METEORITES. Ozerova, N. A.; Kvasha, L. G.; Bulkin, G. A.; Aidinyan, N. Kh. (Inst. of Geology of Mineral Deposits, Petrography, Mineralogy, and Geochemistry, Moscow). Geochim. Cosmochim. Acta; 37: No. 3, 569-582(Mar 1973).

Chemical analyses of mercury in 123 specimens of 58 meteorites are presented. A statistical comparison is made of the mercury content in meteorites (using all available data) as a function of their composition and texture. The average mercury abundance in stony meteorites is estimated as 6.6 ppm. Stony and iron meteorites differ significantly in mercury content. Among stones, chondrites and achondrites show significant differences in the mercury content. In ordinary chondrites, mineralogy and texture do not seem to have a significant influence on the distribution of mercury, judging from the available number of analyses. Carbonaceous chondrites, in which up to 500 ppm mercury was found, stand out among all other varieties of chondrites. Iron meteorites fall at the other extreme, having the lowest mercury concentrations. In specimens of several meteorite classes, troilite is a good mercury concentrator, having a consistently higher mercury content than the meteorite as a whole. Nonetheless, troilite generally accounts for less than one-half the total mercury content of the meteorite. (auth)

**23058** NOBLE GAS AND CARBON ABUNDANCES OF THE HAVEROE, DINGO PUP DONGA, AND NORTH HAIG UREILITES. Bogard, D. D.; Gibson, E. K.; Moore, D. R.; Turner, N. L.; Wilkin, R. B. (Manned Spacecraft Center, Houston, TX). Geochim. Cosmochim. Acta; 37: No. 3, 547-557(Mar 1973).

Total carbon determinations on the Haveroe, Dingo Pup Donga, and North Haig ureilites yield values of 2.07, 3.17, and 5.58 wt. %, respectively. Haveroe and Dingo Pup Donga contain relatively large amounts of trapped Ar, Kr, and Xe, which like the carbon content varies with grain size for Haveroe. These two meteorites also contain dominant cosmic ray-produced He and Ne, and show $^3$He exposure ages of ~23 m.y. and ~7 m.y., respectively. North Haig contains much smaller amounts of trapped gases and spallogenic gases, which may result from loss due to terrestrial weathering. The isotopic composition of Xe in five grain size analyses of Haveroe and a whole rock analysis of Dingo Pup Donga shows the presence of a major solar-like Xe component. The presence of this solar component adds an additional complication to the concept of forming ureilites from carbonaceous chondrites. (auth)

**23059** POLAR COEFFICIENTS AND A GENERALIZATION OF THE SPECTROGRAPHIC METHOD FOR INVESTIGATING COSMIC RAY VARIATIONS OF MAGNETOSPHERIC AND INTERPLANETRAY ORIGIN. Dorman, L. I.; Shkhalakhov, G. Sh. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2420-2426(Nov 1972). (In Russian).

A generalization of the spectrographic method of studying variations in cosmic rays made possible the use of a computer in obtaining polar coefficients. Greater utilization of the data on planetary observations of cosmic rays resulted, wherein the latter had their origin in the magnetoshpere and interplanetary space. (tr-auth)

**23060** ANALYSIS OF COSMIC RAY VARIATIONS OF MAGNETOSPHERIC AND INTERPLANETARY ORIGIN BY MEANS OF SPECTROGRAPHIC DATA. Dvornikov, V. M.; Dorman, L. I.; Luzov, A. A.; Sergeev, A. V.; Yanchukovskii, A. L. Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2427-2434 (Nov 1972). (In Russian).

Two cases of the Forbush effect in cosmic rays were analyzed on November 7, 1970 and January 27, 1971, as recorded by the Irkutsk spectrograph. In the first case a significant change in the hardness of the geomagnetic cutoff was detected, which possessed a quasiperiodic character. (tr-auth)

**23061** EXPERIMENTAL AND THEORETICAL INVESTIGATIONS OF COUPLING COEFFICIENTS AND INTEGRAL MULTIPLICITIES. Avdeev, E. A.; Bednazhevskii, V. M.; Blokh, Ya. L.; Viskov, V. V.; Dorman, L. I.; Manshilina, A. A. Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2451-2459(Nov 1972). (In Russian).

Measurements were made of the broad distribution of the intensity of the neutron component of cosmic rays for the period 1967 to 1969. The coupling/binding/coherent coefficients were computed. The change in these characteristics with the cycle of solar activity was discussed. (tr-auth)

**23062** HEIGHT-WIDTH DEPENDENCE OF PARTIAL COEFFICIENTS AND THE FUNCTION OF THE SPECIFIC YIELD OF THE NEUTRON COMPONENT OF COSMIC RAYS. Granitskii, L. V.; Novikova, G. A.; Rishe, L. E. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Novosibirsk, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2460-2464 (Nov 1972). (In Russian).

Cascade equations were derived from equations of explosive Markov processes, allowing for the unusualness of a stream of random events and being transformed for a continuum. Partial coefficients and functions of the specific neutron components of cosmic rays were used in depths of the stratosphere from 10 to 1000 g/cm$^2$ in the energy range 1 to 16 GeV. (tr-auth)

**23063** ANALYSIS OF DATA QUALITY OF COSMIC RAY RECORDING BY NEUTRON SUPERMONITORS. Aleksan'yan, T. M.; Blokh, Ya. L.; Gulinskii, O. V. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2465-2468(Nov 1972). (In Russian).

Questions as to the quality of the data from a neutron supermonitor were considered, and the dispersion of the data was discussed. Difference in barometric coefficients was investigated. (tr-auth)

**23064** MATHEMATICAL MODEL FOR OPTIMIZING DATA FROM THE OBSERVATION OF COSMIC RAY INTENSITY. Alaniya, M. V.; Kandelaki, N. P. (Inst. of Geophysics, Tbilisi, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2469-2474 (Nov 1972). (In Russian).

A mathematical model was considered for the optimization of cosmic-ray data, which, with the aid of a computer, allowed reduction of the incoming information. Use with a three-channel neutron supermonitor is discussed. Optimization of any given experimental data was possible provided that it was also possible to regard the data as a sum of random quantities. (tr-auth)

**23065** COMPARATIVE CHARACTERISTICS OF THE SOFT COMPONENT OF SOLAR AND GALACTIC COSMIC RAYS ACCORDING TO ROCKET AND STRATOSPHERIC MEASUREMENTS ON o. HEISS AND IN APATITES. Vashenyuk, E. V.; Lazutin, L. L.; Tulinov, V. F.; Tulyakov, V. V. (Polar Inst. of Geophysics, Apatity, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2387-2390(Nov 1972). (In Russian).

A series of rocket measurements of radiation was conducted in the upper atmosphere (to an altitude of 90 km) during the period from September 1968 to August 1970 on o. Heiss (Franz-

Josef Land, $\Phi$-7112°, $\lambda = 155.0°$E). The rocket measurements were compared with ground-level and stratospheric data on cosmic rays on the Apatites station which were of a more regular character and therefore might serve as a reference for the interpretation of the results. (KSW)

**23066** METHODS OF DETERMINING THE CHARGES OF HEAVY PRIMARY NUCLEI ($Z > 26$) IN PHOTONUCLEAR EMULSIONS OF VARIOUS SENSITIVITIES. Varyukhin, V. V.; Ivanova, N. S.; Kulikov, V. N.; Yakubovskii, E. A. (Ioffe Inst. of Physics and Tech., Leningrad). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2396-2399(Nov 1972). (In Russian).

Methods are proposed for determining charges photometrically by the absorption of light at a given distance from the axis of a track and with a given track width. Calculations of the energy of the ionization by E$\delta$-electrons are utilized for constructing the graduated charge curves. The connection between E and the light absorption is derived from measurements of light absorption and track width of the stopping Fe nuclei. (tr-auth)

**23067** INVESTIGATION OF HARD $\gamma$-RAYS IN THE ATMOSPHERE WITH THE AID OF A TELESCOPE WITH AN ACOUSTIC SPARK CHAMBER. Bocharkin, V. K.; Gorodinskii, G. M.; Kruglov, E. M.; Pyatigorskii, G. A.; Romanov, A. M.; Chuikin, E. I. (Ioffe Inst. of Physics and Tech., Leningrad). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2400-2404(Nov 1972). (In Russian).

Data on the high-altitude and energy distribution of hard $\gamma$-rays in the atmosphere are presented. The recording equipment was carried by balloon to geomagnetic latitude = 47° on September 23, 1970. A differential spectrum of $\gamma$-rays with $E_\gamma > 110$ MeV was satisfactorily approximated by the power dependence with $k = 2$ at a depth/intensity of $x = 5.8$ g/cm$^2$. The spectral index increased with depth, attaining a value of 2.8 at $x = 420$ to 200 g/cm$^2$. (tr-auth)

**23068** FREQUENCY SPECTRUM OF VARIATIONS IN COSMIC RAY INTENSITY AND SOLAR ACTIVITY. Kolomeets, E. V.; Chumbalova, R. A.; Shakhova, Yu. A.; Shvartsman, Ya. E.; Shigaev, B. N. (Kazakh State Univ., Alma-Ata, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2405-2410(Nov 1972). (In Russian).

The frequency spectrum of intensity variations of cosmic rays and solar activity was examined in the frequency range 6 to 2.5 x 10$^{-4}$ cycles/24 hr. Solar activity variations corresponded with variations which were assigned to cosmic rays. Periods of 89, 228, 365, and 668 days and 11 years were distinguished in cosmic-ray variations; these coincided with the times of revolution of the planets Mercury, Venus, Earth, Mars, and Jupiter. (tr-auth)

**23069** ENERGY SPECTRUM OF GALACTIC COSMIC RAYS OUTSIDE THE REGION OF MODULATION AND ANISOTROPY OF COSMIC RAYS IN THE GALAXY. Alent'ev, A. N.; Zusmanovich, A. G.; Kolomeets, E. V., (Kazakh State Univ., Alam-Ata, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2411-2416 (Nov 1972). (In Russian).

The energy spectrum of galactic cosmic rays was determined from the recording of cosmic rays on the Earth, obtaining data on those rays external to the modulation region. The energy density of cosmic rays in interstellar space was equal to 2.4 eV/cm$^3$. The anisotropy of cosmic rays in the Galaxy ~0.1% for $E \sim 6 \times 10^{10}$ eV, and the time of the maximum was 19 hours LT. (tr-auth)

**23070** ELBRUS SPECTROGRAPH FOR COSMIC RAYS. Dorman, L. I.; Shkhalakhov, G. Sh. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2417-2419(Nov 1972). (In Russian).

A brief description is given of the Elbrus spectrograph designed for cosmic-ray studies. Evaluations were made of certain meteorological effects at various recording levels. The possibilities of the spectrograph are discussed with regard to isolation and investigation of cosmic-ray variations, as caused by processes occurring within the Earth's magnetosphere and in interplanetary space. (tr-auth)

**23071** ANISOTROPY OF COSMIC RAYS IN THE PERTURBATION PERIOD OCTOBER 25 TO NOVEMBER 10, 1968. Blokh, Ya. L.; Dorman, L. I.; Eroshenko, E. A.; Inozemtseva, O. I. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2383-2386(Nov 1972). (In Russian).

The spatial anisotropy of cosmic rays was explored during the period of disturbance Oct. 25 to Nov. 10, 1968 by means of data on the neutron component of cosmic rays as gathered by a worldwide network of stations. The complex character of the changes during the period was demonstrated and associated with the proton flares on the Sun and with the Forbush effect. The cosmic-ray gradient at the Earth's orbit was computed for November 3. (tr-auth)

**23072** ANTICIPATED GRADIENTS OF COSMIC RAY DENSITY FOR VARIOUS MODELS OF PROPAGATION OF GALACTIC COSMIC RAYS IN INTERPLANETARY SPACE. Dorman, L. I.; Kobilinski, Z. Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2346-2353(Nov 1972). (In Russian).

The results of calculating density gradients of cosmic rays were compared for different modulation models for cosmic radiation in interplanetary space. The theoretically expected values of the transverse components of the gradient agreed in order of magnitude to the observed values at a declination to the Earth of ±7.25° from the plane of the equator. This was the case for the model which accounted for anisotropic diffusion in the vicinities of the Sun and the Earth. (tr-auth)

**23073** DETERMINATION OF POLARIZATION AND ENERGY SPECTRUM OF $\gamma$-QUANTA OF COSMIC RADIATION. Gal'per, A. M.; Kel'ner, S. R.; Kotov, Yu. D.; Logunov, V. M. (Moscow Engineering-Physics Inst.). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2354-2358(Nov 1972). (In Russian).

A method for measuring linear polarization and the energy spectrum of $\gamma$-quanta of cosmic radiation with energies of $E > 1$ MeV was examined. The influence of multiple scattering of electrons and protons produced a considerable error in the measurement of polarization of protons, and allowance had to be made for this. (KSW)

**23074** DATA ON THE HEAVY PRIMARY NUCLEI ($Z \geq 33$) PRODUCED BEYOND THE MAGNETOSPHERE OF THE EARTH. Ivanova, N. S.; Varyukhin, V. V.; Kulikov, V. N.; Yakubovskii, E. A. Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2359-2362 (Nov 1972). (In Russian).

Fluxes of nuclei of the Fe group ($Z \geq 24$) outside the Earth's magnetosphere were evaluated at two energy intervals: $\Phi_{Fe}$ ($E_{Fe} \geq 150$ MeV/N) = $0.47 \pm 0.06$ particle/m$^2$·ster·sec; $\Phi_{Fe}$ ($E_{Fe} \geq 1$ GeV/N) = $0.23 + 0.04$ particle/m$^2$·ster·sec. The relative contents (relative to the Fe group) of heavy nuclei with $Z \geq 33$, $Z \geq 40$, etc., for relativistic nuclei ($E \geq 1$ GeV/N) and slower, were cited at energies 150 MeV/N $\leq E <$ 1 GeV/N. The upper limit of antinuclei was estimated to be 0.05%. (tr-auth)

**23075** PROBLEMS IN LINEAR AND NONLINEAR THEORY OF COSMIC RAY MODULATION. Belov, A. V.; Dorman, I. V.; Dorman, L. I.; Shakhov, B. A. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2324-2331(Nov 1972). (In Russian).

The effect of a moving magnetic screen on cosmic rays was investigated. Model-derived calculations of intensity changes, density, and anisotropy of cosmic rays are offered for growth prior to the Forbush decrease and for the Forbush decrease. The nonlinear action of cosmic rays with the solar wind and the problem of limitation of the region of modualtion were investigated. (tr-auth)

**23076** COSMIC RAY VARIATIONS IN THE PAST. Dergachev, V. A.; Kocharov, G. E. (Ioffe Inst. of Physics and Tech., Leningrad). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2312-2318 (Nov 1972). (In Russian).

The radiocarbon content in dated samples was utilized in an attempt to investigate cosmic-ray variations. Calculated results based on such data sources were adduced, and conclusions were drawn regarding the flare activity of the Sun, the intensity of the cosmic rays over the course of time from the outburst of a supernova to the present, and changes in the magnetic field of the Earth. (tr-auth)

**23077** SPATIAL VARIATIONS OF COSMIC RAYS ACCORDING TO DATA OF THE RADIOACTIVITY OF METEORS WITH KNOWN ORBITS. Lavrukhina, A. K.; Gorin, V. D.; Ustinova, G. K. (Inst. of Geochemistry and Analytical Chemistry, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2306-2311(Nov 1972). (In Russian).

The activity of cosmogenic isotopes $^{26}$Al and $^{22}$Na was measured in the stony meteorites Przhibram and Lost City with aphelions at 4.05 and 2.35 AU, respectively, from the Sun. A comparison with calculated results led to a conclusion regarding the constancy of the galactic cosmic-ray intensity with $E > 0.2$ GeV/nucleon in the region of interplanetary space between 2 and 4 AU, in both a period of 19 and 20 cycles of solar activity and for the last million years. (tr-auth)

**23078** PROPAGATION OF COSMIC RAYS IN THE GALAXY. Bulanov, S. V.; Dogel, V. A.; Ptuskin, V. S.; Syrovatskii, S. I.

(Lebedev Inst. of Physics, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2292-2296(Nov 1972). (In Russian).

During a study of cosmic rays, a comparison of the spectra of electrons, radiowaves, and the chemical composition of cosmic rays, leads to a galactic model with a halo. The half-thickness of the halo S ≈ 1 kps (kiloparsec), and the time of escape of a particle from the galaxy $T \approx 2 \times 10^7$ years. The index of the spectrum of the electron source $\gamma_0 \approx 2.2$. (tr-auth)

**23079** TRANSPORT THEORY FOR COSMIC RAYS WITH ANISOTROPIC SCATTERING OF PARTICLES AND CONVECTION. Zakharchenko, V. F. (Inst. of Geophysics, Sverdlovsk, USSR) Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2265-2270 (Nov 1972). (In Russian).

It is shown on the basis of the Fokker–Planck equation that in a homogeneous medium the steady-state distribution of particles with below-critical energies is nonisotropic in the presence of a uniform magnetic field. In the energy region of tens of MeV's, the transverse (with respect to the uniform field) coefficient of dissociation had an anomalous character. Tensor components of anisotropic convection were adduced. (tr-auth)

**23080** COSMIC RAY DISTRIBUTION IN THE INTERPLANETARY MAGNETIC FIELD ON THE BASIS OF A KINETIC EQUATION. Dorman, L. I.; Kats, M. E. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2271-2277(Nov 1972). (In Russian).

A kinetic equation was introduced which describes the motion of charged particles in a random magnetic field. Conclusions were generalized from this equation, for which the normal distribution law for fluctuations of a random magnetic field was not assumed. The method used permitted a description of both fluctuations in the magnetic field and also fluctuations in the velocity of the solar wind. (KSW)

**23081** CAPTURE OF PRIMARY COSMIC RADIATION IN THE UPPER ATMOSPHERE AS A SOURCE OF EXCESS RADIATION. Morozov, D. Kh. Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2447-2450(Nov 1972). (In Russian).

The mechanism of capture of primary galactic radiation by the magnetosphere as a result of ionization loss is suggested as one of the sources of excess radiation. The number of charged particles involved was estimated. The spectrum of VH group of nuclei moving in the plane of the magnetic equator was calculated. (tr-auth)

**23082** FORBUSH DECREASES AND THEIR CONNECTION WITH SOLAR ACTIVITY AND THE PARAMETERS OF INTERPLANETARY MEDIUM. Dorman, L. I.; Kaminer, N. S.; Kuz'micheva, A. E. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2391-2395(Nov 1972). (In Russian).

The relation between the amplitudes of Forbush decreases and the prior growth in cosmic-ray intensity and the different characteristics of solar activity and the parameters of interplanetary space in cycles 19 and 20 of solar activity were considered. The effects in cosmic rays were investigated in those periods when the heliolatitude of the Earth was $\varphi \leq 2°$. (tr-auth)

## Stars

*Refer also to abstracts 23094, 23287, and 23749.*

**23083** 5 GHz OBSERVATIONS OF THE INFRARED STAR MWC 349, AND THE H II CONDENSATION W3(OH). Baldwin, J. E.; Harris, C. S.; Ryle, M. (Cambridge Univ., Eng.). Nature (London); 241: No. 5384, 38-39(5 Jan 1973).

MCW 349 was observed with the Cambridge 5 km radiotelescope. It showed a flux density of 0.22 ± 0.01 fu at 5 GHz. Details were also obtained of angular diameter, position, and distance. The angular size and flux densities were consistent with thermal emission from a region having an electron temperature of 9000 K and an emission measure of $2.7 \times 10^7$ $xm^{-6}$ p.c. The close similarity of this temperature to the value found for many H II regions gives strong support for a thermal explanation for the radio emission. Assuming a distance of 2.1 kpc, on the basis of the possible association of MWC 349 with the Cygnus OB2 association, the diameter of the radio source is 0.024 pc and the electron density $3.4 \times 10^4/cm^3$, corresponding to a mass of ionized gas of $9 \times 10^{-3}\ M_\odot$. It was of interest to compare this source with the continuum emission from W3(OH), the compact component associated with OH emission in the H II region W3, details of which are given. (UK)

**23084** SPECTRUM OF A DUST-EMBEDDED WOLF–RAYET STAR IN CYGNUS OB2. Bromage, G. E.; Nandy, K. (Royal Observatory, Edinburgh). Nature (London) Phys. Sci.; 241: No. 106, 30-31(8 Jan 1973).

It has been suggested that three Wolf–Rayet stars may be members of the Young association Cyg OB2, and from UBV photometry it has been indicated that they are heavily obscured, most of the reddening being caused by circumstellar dust shells. As part of a wider programme of study of diffuse interstellar spectral features the brightest of these stars, WR2, was examined. The spectrum was obtained at a dispersion of 60 Å/mm with the Isaac Newton telescope, over the wavelength range 565 to 685 mm, and a microdensitometer tracing of the spectrum is reproduced. The diffuse interstellar absorption features were very strong, and their wavelength positions were apparently the same as for other stars in the Cygnus OB2 association. The results imply that the sources of the diffuse features in the spectrum of WR2 are not closely circumstellar in origin. The absolute magnitude of WR2 was found to be −7.7 ± 1.4. This seems to be the first evidence of a WN star of type other than WN7 or 8 having a magnitude brighter than −5. (UK)

**23085** NUMERICAL EXPERIMENTS CONCERNING ISOLATED AND NON-ISOLATED STELLAR SYSTEMS. Bouvier, P. (Geneva Observatory). Comput. Phys. Commun.; 4: No. 3, 345-346(Dec 1972).

A brief review is given of the principal methods used to deal with the dynamics of stellar systems, mostly star clusters, which are nearly all, at least partly, relaxed with respect to stellar encounters; particular stress is laid upon the direct numerical integration of the N-body problem. (auth)

**23086** MAGNETIZED ROTATING SPHERE. Ruffini, R. (Joseph Henry Physical Labs., Princeton, NJ); Treves, A. Astrophys. Lett.; 13: No. 2, 109-113(Feb 1973).

The issue of the most stable electromagnetic structure associated with a rotating sphere with a magnetic axis, aligned to the rotation axis, is discussed. With a classical model it is shown that the configuration that minimizes the total electromagnetic energy of the system is endowed with a nonzero net charge. Some implications for the physics of collapsed objects are stressed. (auth)

**23087** INFRARED SPECTRUM AND ANGULAR SIZE OF ETA CARINAE. Gehrz, R. D. (Univ. of Minnesota, Minneapolis); Ney, E. P.; Becklin, E. E.; Neugebauer, G. Astrophys. Lett.; 13: No. 2, 89-93(Feb 1973).

The angular size of the infrared source associated with the peculiar optical object $\eta$ Carinae was measured at wavelengths from 2.2 to 18 μm. At 2.2 μm the angular diameter was 2 arc sec. The size increased with increasing wavelength and was 6 arc sec diameter at 10 and 18 μm. The solid materials responsible for the thermal radiation have a temperature of about 425 K for the inner shell and 250 K for the outer region. Metallic silicates appear to be present in the cool shell, and the optical depth at 10 and 18 μm was estimated at $\tau \cong 0.3$. The observed bolometric magnitude of −11.5 is mostly produced by the cool shell, which in turn must be powered through the absorption of shortwave radiation emitted by a central object of corresponding bolometric magnitude. No significant variation in the 10-μm brightness of Eta Carinae has occurred between mid 1968 and late 1972. (auth)

**23088** INFRARED OBJECT PROBABLY ASSOCIATED WITH OH 338.5 + 0.1. Glass, I. S. (Royal Greenwich Observatory, Hailsham, Eng.); Feast, M. W. Astrophys. Lett.; 13: No. 2, 81-83(Feb 1973).

A bright infrared object has been found near OH 338.5 + 0.1. JHKL photometry is given. The spectral type in the visual region is approximately M3. VY CMa and VX Sgr are the only other OH–IR sources having such early spectral types. Both VY CMa and OH 338.5 + 0.1 may be connected with dark clouds. Both the OH and optical observations yield a high negative radial velocity for this source. (auth)

**23089** OBSERVED DEFICIENCY OF IONIZED GAS IN GLOBULAR CLUSTERS AND THE COMPANIONS OF M31. Hills, J. G. (Univ. of Michigan, Ann Arbor); Klein, M. J. Astrophys. Lett.; 13: No. 2, 65-68(Feb 1973).

An ultra-sensitive search at 3.8 cm for free–free emission from ionized gas in the globular clusters M3, M5, M13, M75, and M92 and the two galactic companions of M31 reveals no radiation above the experimental error which is typically $4 \times 10^{-29}$ $W\ m^{-2}\ Hz^{-1}$. The upper limit on the amount of gas in most of these systems is about an order of magnitude below that computed on the assumption that the mass shed by evolving stars has been retained in the systems. For the gas to have escaped these systems, the evolving stars had to eject it at minimum average velocities which range from about 100 km/sec near the center of some globular clusters to over 400 km/sec for the average star in NGC 205 or M32. Collisions among the gas shells ejected by various stars within any of the observed systems are ineffective in preventing the escape of the gas because the time scale for the radiative cooling of the gas heated in such collisions is very much longer than the time required for it to escape these small systems. (auth)

**23090** DYNAMICAL EFFECTS OF THE CURVATURE OF PARTICLE TRAJECTORIES IN THE TWO-BODY PROBLEM WITH CORPUSCULAR RADIATION. Omarov, T. B. (Astrophysical Inst., Alma-Ata, USSR). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 709-713(1973).

Translated from Astron. Zh.; 49: No. 4, 872-878(1972).

An analysis is given of the relative motion of the components of a binary system emitting corpuscular radiation, allowing for gravitational interaction with the system and assuming that the moderately high velocity of particle ejection from the surface of the bodies is independent of time. The differential equation for this generalized formulation of the two-body problem with variable mass is investigated by means of the intermediate motion proposed earlier by the author and by Hadjidemetriou in papers published simultaneously. If a quite general condition holds, the eccentricity of the corresponding osculating orbit will experience no systematic variations, while the pericenter will be subject to a secular perturbation, for which an equation is derived. (auth)

**23091** OPEN CLUSTER NGC 6866. Koroleva, L. S. (Central Astronomical Observatory, Pulkovo, USSR). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 643-650(1973).

Translated from Astron. Zh.; 49: No. 4, 786-795(1972).

The existence of a corona around NGC 6866 and the superposition of field stars on the cluster are discussed. From two criteria 93 members in the outer regions of the cluster have been definitely identified; thus, a corona certainly exists in this part of the stellar background. The observational material at hand does not permit an estimate of the size of the corona, but its density appears to be constant to within random fluctuations. A careful identification of 60 definite members was previously made from U, B, V photometry at the U. S. Naval Observatory. Now, 92 additional inner cluster members and 93 outer members are listed. Color—magnitude and vector-proper motion diagrams are given for these stars. (auth)

**23092** PROPOGATION OF SHOCK WAVES IN A ROTATING STAR. Rumyantsev, A. A. (Leningrad Polytechnic Inst.). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 610-614(1973).

Translated from Astron. Zh.; 49: No. 4, 744-749(1972).

The emergence of a strong shock wave into the outer layers of a rotating star is analyzed. Because of the anisotropic density gradient in such a star, the shock front will form a figure of revolution elongated toward the poles, even in the event of centrally symmetric energy production. The detached envelope will assume a corresponding shape. Estimates for novae and supernovae indicate that the preferential poleward mass ejection will increase with the star's angular rotational velocity. The influence of the regular stellar magnetic field on the formation of the envelope is discussed. The field is substantial at maximum light and may lead to the generation of equatorial surges and belts. (auth)

**23093** POLARIZATION OF OPTICAL RADIATION OF STARS WITH NONSPHERICAL ATMOSPHERES AND ENVELOPES. Gnedin, Y. N.; Dolginov, A. Z.; Silant'ev, N. A. (Ioffe Inst. of Physics and Tech., Leningrad). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 567-575(1973).

Translated from Astron. Zh.; 49: No. 4, 689-699(1972).

The polarization of optical radiation due to scattering by freely oriented anisotropic molecules or dust particles in nonspherical stellar atmospheres or envelopes is considered. It is shown that the polarization is smaller than that arising from Rayleigh scattering. The polarization increases when there is absorption. The results of polarimetric measurements on red giants and magnetic and x-ray stars are discussed. The magnetic field of the x-ray star Sco X-1 is estimated. (auth)

## Quasi-Stellar, Radio, and X-Ray Sources

*Refer also to abstract 23083.*

**23094** LAMBDA-SCO, A POSSIBLE SOURCE OF SOFT X-RAYS. Bleeker, J. A. M. (Kamerlingh Onnes Lab., Leiden); Deerenberg, A. J. M.; Heise, J.; Yamashita, K.; Tanaka, Y. Nature (London) Phys. Sci.; 241: No. 107, 55-56(15 Jan 1973).

The detection of a strong soft x-ray source in a direction near the galactic center is reported, using an x-ray telescope flown on May 26, 1971 from Kauai. The measured counting rate of this soft source was approximately $0.6/cm^2/s$ for the energy range 0.37 to 1.9 keV. The bright star $\lambda$ Sco is close to the edge of the error box; this is a spectroscopic binary with a period of 5.6 days and at a distance estimated as 100 pc. If this star is the soft x-ray source the luminosity in the energy band 0.37 to 1.9 keV would be $2 \times 10^{33}$ ergs/s. (UK)

**23095** 2.8 CM RADIO EMISSION FROM $\alpha$ ORIONIS, HBV 475, AND MWC 349. Altenhoff, W. J.; Wendker, H. J. (Max Planck-Institut fuer Radioastronomie, Bonn). Nature (London); 241: No. 5384, 37-38(5 Jan 1973).

The Max-Planck Institute (Bonn) 100 m telescope was used in a search for radio emission from stars believed to have ejected or to be ejecting matter. Amongst stars detected were $\alpha$-Ori, HBV 475, and MWC 349, observed during October 1972. The average of the azimuth scans through $\alpha$-ORI is shown plotted; the derived flux is well below the values reported by previous observers, and it is suggested that it represents the normal radio intensity at 2.8 cm; and that previous observers detected outbursts in which the flux was temporarily higher. This suggestion is supported by the fact that no significant difference was found between observations made three days apart. If a diameter of 0.034 arc s is assumed for the source the brightness must be about $10^5$ K; if, on the other hand, the brightness temperature is that of the photospheric temperature of the star, namely 3500°K, a diameter of 0.18 arc s is obtained. The real values will lie between these limits. With regard to HBV 475 it is tentatively suggested that the radio emission originates in an extended atmosphere that also emits the optical emission lines, and with regard to MWC 349, which showed a change in flux density over two nights, it is thought that it is a variable radio source, possibly of the Antares type. (UK)

**23096** SOFT X-RAY PULSATIONS FROM PSR 0833-45. Harnden, F. R.; Gorenstein, P. (American Science and Engineering, Inc., Cambridge, MA). Nature (London); 241: No. 5385, 107-108(12 Jan 1973).

The radio pulsar PSR 0833-45 was the first pulsar to be associated with a supernova remnant. This SNR is the site of the nonthermal radio source Vela X and has also been observed to be a region of soft x-ray emission. Observations of the x-ray structure of the Vela SNR in the energy range 0.1 to 1.5 keV are described, made with a scanning focusing collector flown on an Aerobee 170 sounding rocket fired from the White Sands Missile Range on April 1, 1972. It was found that the x-ray source in the Vela SNR consists of a continuous extended region with a structure consistent with a point source at the position of PSR 0833-45. Results pertaining only to the latter are reported. The counting rate for the energy range 0.5 to 1.5 keV is shown as a function of angle during a scan along a great circle approximately parallel to the galactic equator but displaced by several degrees. The x-ray source in the Vela SNR was found to consist of an x-ray nebula not resolvable into point sources, plus a peaking of the intensity at the position of PSR 0833-45 consistent with a point source, about 2° from the center of the Vela x-ray nebula. For the 0.5 to 1.5 keV energy range the intensity of the feature at PSR 0833-45 above nebula background was equal to 6.2 ± 2.6% of the intensity of the entire Vela x-ray nebula. A search was made for possible periodic pulsations from the direction of PSR 0833-45. Data are also plotted for the distribution in phase of radio counts detected from the vicinity of PSR 0833-45 for an assumed period of 0.08922s, in comparison to x rays. The detection of pulsations, in addition to localised emission about PSR 0833-45, strengthens the case that the pulsar is a point source of x rays, and this should reserve any doubt about its intimate connection with the Vela SNR. Comparisons are made with the Crab system. Implications for pulsar models are also briefly discussed. (UK)

**23097** OBSERVATIONS OF PERIODIC VARIATIONS IN THE X-RAY INTENSITY OF CYGNUS X-3. Canizarex, C. R.; McClintock, J. E.; Clark, G. W.; Lewin, W. H. G.; Schnopper, H. W.; Sprott, G. F. (Massachusetts Inst. of Tech., Cambridge). Nature (London) Phys. Sci.; 241: No. 106, 28-30(8 Jan 1973).

A study is described of the time variability of the x-ray intensity of Cygnus X-3 from data collected by the OSO-7 satellite in December 1971 and during January, June, and July 1972, using an Ar-filled proportional counter sensitive from 3 to 10 keV. The counting rate as a function of time for each sighting is shown, indicating a periodic behavior of the source. The average intensity was not constant, the means for December and June differing by more than a factor of three, and the shape of the data curves was not the same for all sightings. Also in addition to the periodic variations there were fluctuations from cycle to cycle with time scales of tens of minutes. The observations could be combined to give a period of 0.199667 ± 0.000014 day. (UK)

**23098** EVOLUTION OF THE CRAB NEBULA. Pacini, F.; Salvati, M. (Laboratorio di Astrofisica Spaziale, Frascati, Italy). Astrophys. Lett.; 13: No. 2, 103-104(Feb 1973).

The time evolution of the magnetic field strength in the Crab Nebula was investigated. It is shown that the Crab Nebula cannot contain any energetic particles produced during the early phases. (auth)

**23099** RADIO SOURCES WITH ENHANCED SPECTRA AT CENTIMETER WAVELENGTHS. Stull, M. A.; Carpenter, R. D. (Univ. of Michigan, Ann Arbor). Astrophys. Lett.; 13: No. 2, 73-75(Feb 1973).

8000-MHz flux densities are given for 32 radio sources having flat or enhanced high-frequency spectra. (auth)

**23100** ADS 2859 B AS AN ALTERNATIVE CANDIDATE TO X PER FOR THE X-RAY SOURCE 2U 0352 + 30. Haupt, W.; Moffat, A. F. J. (Ruhr Univ., Bochum, Ger.). Astrophys. Lett.; 13: No. 2, 77-79(Feb 1973).

ADS 2859 B, like X Per (ADS 2859 A), lies very near to the most likely position of the Uhuru x-ray source 2U 0352 + 30. UBV observations show that ADS 2859 B exhibits extreme T Tauri-like characteristics. Its total luminosity ($\sim 10\ L_\odot$) and colors suggest that it is a pre-main-sequence object with a mass $\sim 2\ M_\odot$ and an age $\sim 10^6$ yr. (auth)

**23101** POLARIZATION OF OPTICAL RADIATION AND MAGNETIC FIELD OF X-RAY STARS. Dolginov, A. Z.; Gnedin, Yu. N.; Silant'ev, N. A. (Ioffe Inst. of Physics and Tech., Leningrad). Astrophys. Lett.; 13: No. 2, 85-87(Feb 1973).

Circular polarization of the optical radiation from x-ray stars was calculated on the assumption that magnetoactive plasma is a source of continuous optical radiation of these stars. The influence of a strong magnetic field on the linear polarization of radiation is briefly discussed. (auth)

**23102** INTERSTELLAR SCATTERING AND THE ANGULAR DIAMETERS OF OH COMPONENTS. Little, L. T. (Univ. of Kent, Canterbury, Eng.). Astrophys. Lett.; 13: No. 2, 115-118 (Feb 1973).

The possibility that the apparent angular diameters of OH source components in W3, W24, and W49 are due to scattering of their radiation by plasma irregularities in the intervening medium is considered. Although the angular diameter of W3(OH) may be produced by general interstellar scattering, this is unlikely to be the case for W49. On the other hand, the probability that the lines of sight to W24 and W49 are intercepted by H II regions (ionized by hot O and B stars) seems quite high. Evidence from scattering observations of PSR 0833-45 suggests that such H II regions are capable of producing the required angular broadening. (auth)

**23103** DISCOVERY OF INTERSTELLAR METHANIMINE (FORMALDIMINE). Godfrey, P. D. (Monash Univ., Melbourne); Brown, R. D.; Robinson, B. J.; Sinclair, M. W. Astrophys. Lett.; 13: No. 2, 119-121(Feb 1973).

The $1_{10}-1_{11}$ transition of methanimine $H_2C=NH$ has been detected in emission in the spectrum of Sagittarius B2 with the Parkes 64-m telescope. The frequencies of the observed multiplet, near 5.290 GHz, agree well with the multiplet detected in the laboratory, if a radial velocity of $63 \pm 2$ km sec$^{-1}$ is adopted for the Sgr B2 emission. (auth)

**23104** QUASIRADIAL PULSATION OF ROTATING RELATIVISTIC MODELS. Papoyan, V. V.; Sedrakyan, D. M.; Chubaryan, E. V. (Erevan State Univ.). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 615-618(1973).

Translated from Astron. Zh.; 49: No. 4, 750-755(1972).

An analysis is given of low-amplitude adiabatic radial pulsations about the equilibrium states of slowly rotating relativistic models. The relativistic equation of hydrodynamic equilibrium is derived, as well as equations of small perturbations due to pulsation, taking into account the relativistic rotation corrections in the $\Omega^2$ approximation. For a fluid model with a homogeneous mass distribution the dynamical instability associated with the relativistic effects of the mass distribution is found to be compensated by the rotation effects. (auth)

**23105** POLARIZED RADIATION OF RELATIVISTIC ELECTRONS SCATTERED BY PLASMA TURBULENCE. Tsytovich, V. N.; Kaplan, S. A. (Radiophysics Inst., Gorky, USSR). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 722-723(1973).

Translated from Astron. Zh.; 49: No. 4, 890-892(1972).

Even in a weak magnetic field, with $\omega_{H,e} = eH/m_ec \ll \omega_{p,e} = (4\pi ne^2/m_e)^{1/2}$, the high-frequency ($\omega \gg \omega_{p,e}$) radiation due to Compton scattering of relativistic electrons by turbulence fluctuations in plasma will not only have a power-law spectrum $I_\omega \sim \omega^{-\alpha}$, but will also be polarized. Unlike the case with synchrotron radiation, the preferred direction of vibration of the electric vector will be aligned with the external magnetic field. For isotropic relativistic electrons with the power-law energy spectrum $f_\epsilon \sim \epsilon^{-\gamma}$ [$\alpha = (\gamma - 1)/2$], the degree of polarization $\Pi = (\gamma + 1)(\gamma + 3)/(\gamma^2 + 4\gamma + 11)$, so that $\Pi = 75\%$ if $\gamma = 3$. For a directed beam of relativistic electrons $\Pi$ can reach 100%, and its average value over the solid angle of emission would be 57%. (auth)

**23106** POPULATION OF THE SECOND LEVEL OF THE HYDROGEN ATOM IN A PLASMA MEDIUM. Kleiman, E. B. (Gorky State Univ., USSR). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 724-725(1973).

Translated from Astron. Zh.; 49: No. 4, 892-895(1972).

Sublevel populations of the second level of the hydrogen atom are derived, taking into account the induced 2S – 1S photon – plasmon transition. (auth)

**23107** DISTRIBUTION OF POLARIZED 3.5-mm RADIATION IN THE CRAB NEBULA. Matveenkov, L. I.; Conklin, E. K. (Inst. for Space Research, Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 726-727(1973).

Translated from Astron. Zh.; 49: No. 4, 895-897(1972).

The linearly polarized 3.5-mm radiation of the Crab Nebula was mapped with the 11-m radio telescope of the NRAO at Kitt Peak. The 3-dB isophote measures $1.3 \times 2.0$, with its maximum shifted by $\Delta\alpha = +20 \pm 15''$, $\Delta\delta = -20 \pm 15''$ relative to the pulsar. The average polarization is $(6.5 \pm 0.3)\%$; the peak value $(23 \pm 3)\%$. (auth)

**23108** LUNAR OCCULTATIONS OF RADIO SOURCES AS A TECHNIQUE FOR INVESTIGATING THEIR ANGULAR STRUCTURE. II. Abramyan, G. L. (Radiophysics Inst., Gorky, USSR). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 728-729(1973).

Translated from Astron. Zh.; 49: No. 4, 897-899(1972).

A condition is derived for optimum choice of the limiting angular resolution when analyzing lunar occultations of radio sources. (auth)

**23109** COSMIC MASER WITH FEEDBACK. Letokhov, V. S. (Inst. of Spectroscopy, Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 604-609(1973).

Translated from Astron. Zh.; 49: No. 4, 737-743(1972).

A cosmic maser-generator model with resonance-scattering feedback is investigated theoretically. In such a system, unlike the traveling-wave maser-amplifier model, radiation is amplified not on just one, but on a large number of passes. Estimates are obtained for OH and $H_2O$ amplifying clouds. (auth)

**23110** DETECTION OF A $\gamma$-QUANTUM FLUX FROM THE DIRECTION OF THE CONSTELLATION CYGNUS. Vladimirskii, B. M.; Pavlov, I. V.; Stepanyan, A. A.; Fomin, V. P. Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2281-2284(Nov 1972). (In Russian).

Observations were made from August to October, 1970, of several sources at a declination of 35°20′ in one scanning: the pulsar JP 1946, x-ray source Cyg XR-1, the plane of galactic equator, the Cyg Loop region, and the neutral particle source found by Hesse, Falbot, and Cowan (1967). An increase in the count rate was observed which coincided with the instant of passage through the receiving cones of the galactic equatorial plane; the latter, then, was the most probable source of a flux of $\gamma$-quanta of high energy. (KSW)

**23111** SPIN ALIGNMENT OF OH MOLECULES BY INFRARED RADIATION. Burdyuzha, V. V.; Varshalovich, D. A. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 597-603(1973).

Translated from Astron. Zh.; 49: No. 4, 727-736(1972).

The pumping of OH molecules by a directed beam of infrared radiation at $\lambda \approx 100\ \mu$ is discussed. The magnetic-sublevel populations are calculated for the rotational states of the band and for selected angles between the directions of the infrared beam and the magnetic field. Specific optical thicknesses $\tilde{\tau}$ ($\tilde{\tau} = \tilde{\tau} n_{OH} l$) are computed for the radio lines corresponding to transitions between the $\Lambda$-doublet levels of the states $J = 3/2$ ($^2\Pi_{3/2}$, $\nu = 0$), at 1612, 1720 MHz, and $J = 5/2$($^2\Pi_{3/2}$, $\nu = 0$) at 6016, 6049 MHz. The dependence of $\tilde{\tau}$ on the angle between the field and the line of sight is determined for components of differing polarization. Pumping by directed infrared radiation will serve to redistribute the OH molecules over their hyperfine-structure levels and to align their spins. As a result either enhancement or anomalous absorption will occur, and resonance radio waves propagated through a medium containing OH molecules will be linearly polarized. A method is proposed for establishing the direction of the magnetic field in such a medium. (auth)

**23112** PERIODIC COMPONENTS IN THE FLUX-DENSITY VARIATION OF THE RADIO SOURCE VRO 42.22.01 (BL LACER-

TAE). Gorshkov, A. V.; Popov, M. V. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 593-596(1973).

Translated from Astron. Zh.; 49: No. 4, 722-726(1972).

Fourier analysis was applied to identify periodic components in the flux density of VRO 42.22.01 at $\lambda = 2.8$, 3.75, and 4.5 cm. A pulsating magnetic rotator model is proposed to explain the variations. The basic variations would arise from pulsations of period $T_1 = 140$ days; these would be modulated by rotation in a period $T_2 = 450$ days. An analysis of the radio spectrum implies that the object is double, with one component having a constant radio brightness. (auth)

**23113** AUTOCORRELATION FUNCTION FOR THE RAPID LIGHT VARIATIONS OF THE QUASAR 3C 273. Ozernoi, L. M.; Chertoprud, V. E. (Lebedev Inst. of Physics, Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 585-592(1973).

Translated from Astron. Zh.; 49: No. 4, 712-721(1972).

From Smith's data (private communication) on the brightness variations of 3C 273 over the past 80 yr, the 9-yr cyclic component was subtracted and the autocorrelation function derived for the residual "rapid" variations. The ACF exhibited two regions of decrease, with characteristic times $\tau_1 \gtrsim 0.1$ to 0.2 day and $\tau_2 \approx 1$ yr. The results of the analysis were compared with various theoretical views as to the nature of quasar optical variability. Difficulties arise in attempting to interpret the ACF in terms of supernova outbursts or an accreting "black hole." Possible sources of the observed "rapid" light variations are discussed. (auth)

**23114** NATURE OF THE HIGH VELOCITIES OF $H_2O$ SOURCES IN W49. Strel'nitskii, V. S.; Syunyaev, R. A. (Inst. of Applied Mathematics, Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 579-584(1973).

Translated from Astron. Zh.; 49: No. 4. 704-711(1972).

In view of the observed high dispersion of the radial velocities the system of $H_2O$ sources in W49 should be dynamically unstable, and the cause of their dispersal originated no more than $10^3$ years ago. The most probable model of these sources is a dispersing system of light compact clouds of neutral gas around a hot supergiant or massive protostar. Possible mechanisms are discussed for accelerating the clouds: a stellar wind, a "reactive" mechanism, and the radiation pressure of the central object. A possible connection between the acceleration mechanism and the maser pumping is pointed out. (auth)

**23115** OBSERVATIONS OF COMPACT RADIO-EMITTING OBJECTS AT 3.55 cm WITH MAXIMUM ANGULAR RESOLUTION. Clark, B. J.; Broderick, J. J.; Efanov, V. A. (National Radio Astronomy Observatory, Greenbank, WV). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 576-578(1973).

Translated from Astron. Zh.; 49: No. 4, 700-703(1972).

The first results of measuring the diameters of compact radio sources at a wavelength of 3.55 cm are presented, using Simeiz, Goldstone, and Greenbank for radio interferometry. (auth)

## Solar Phenomena

*Refer also to abstracts 23082, 23226, and 23326.*

**23116** (NP-19682) SOLAR FLARE OF 11 FEBRUARY 1970, 0706 U. T. Technical Note 6. Watkins, B. J. (Department of Supply, Melbourne (Australia). Antarctic Div). Dec 1971. 24p. Dep. NTIS (U. S. Sales Only) $3.25.

A solar flare (Class X, Importance 2B) of February 11, 1970, 0706 U.T., was unusual in that a simultaneous enhancement of ionospheric total electron content occurred. This electron content charge inferred large, long, wavelength increases associated with the flare. The main bases of conclusions drawn from flare measurements discussed in this report have originated from the work of Donnelly in the study of sudden frequency deviations during flares, and previous measurements of electron content increases during a similar flare. An attempt was made to compare x-ray and euv measurements, but little information, however, could be obtained for the longer wavelength portion of the flare spectrum. (auth)

**23117** CLASSIFICATION OF PARTICLE MOTIONS IN THE EQUATORIAL PLANE OF A GRAVITATIONAL MONOPOLE–QUADRUPOLE FIELD IN NEWTONIAN MECHANICS AND GENERAL RELATIVITY. Armenti, A. Jr. (Temple Univ., Philadelphia). Celestial Mech., 6: No. 4, 383-415(Dec 1972).

The motion of particles in a gravitational monopole–quadrupole field is considered both in Newtonian mechanics and the general theory of relativity. The Newtonian calculations are based on the first and third terms in the familiar multipole expansion of Laplace for axially symmetric matter; the relativistic ones are based on the Erez–Rosen metric, an exact solution of Einstein's vacuum field equations. Use is made of the mathematical equivalence between the Newtonian equations of motion in the plane of symmetry and the general relativistic equations in the spherically symmetric Schwarzschild field. By an extension of the method used by Morton and Leavitt to obtain the Schwarzschild geodesics, exact solutions for the Newtonian orbits are obtained in terms of Jacobian elliptic functions, and a complete classification of the orbits is given. The motions are all quasi-Keplerian, except for a curious subclass of orbits corresponding to a form of two-body capture. Approximate equatorial geodesics in the general relativistic case are also found and classified. The lowest order solutions, which are essentially a superposition of relativistic monopole (Schwarzschild) and Newtonian quadrupole contributions, are shown to give accurate descriptions for motions in the solar system. In higher order solutions, purely relativistic (but observationally insignificant) cross terms appear. The results are used to study the effect of a solar oblateness on the three classical tests of general relativity. (auth)

**23118** EVIDENCE FOR POLARISED RADIATION FROM THE SUN IN THE FAR INFRARED. Dall'Oglio, G.; Gandolfi, E.; Melchiorri, B.; Melchiorri, F.; Natale, V. (Laboratorio TeSRE-CNR, Florence). Infrared Phys.; 13: No. 1, 1-6(Jan 1973).

During a balloon-borne experiment intended to study the state of polarization of the far infrared radiation in the 100 to 2000 micron range, a signal was detected from the Sun corresponding to a linear polarization of at least 6.4% assuming a constant polarization over the whole infrared bandwidth observed (wavelengths longer than 500 microns cannot significantly contribute to the observed signal even if they are completely polarized). The vibrational plane is parallel to the Sun equator within 5%. (auth)

**23119** INFRARED INTERFEROMETRY. Gay, J.; Journet, A. (Observatoire de Paris, Meudon, France). Nature (London) Phys. Sci.; 241: No. 106, 32-33(8 Jan 1973).

The heterodyne detection of the Sun at 10.6 $\mu$m is reported, using an infrared interferometer. The mixing element was a Hg–Cd–Te photodiode with a bandwidth of about 400 MHz and the local oscillator was a $CO_2$ laser tuned to 10.6 $\mu$m on the P20 ray. The detected currents were amplified by UTO 511 Avantek amplifiers having band widths from 5 to 500 MHz. The solar diameter was resolved with an interferometer base of 1mm. Recorded fringes are shown, together with fringe amplitudes as a function of the baseline. A calculated Sun diameter of about 33′ was found. Because of its favourable signal-to-noise ratio heterodyne detection is found to be an attractive technique in the infrared. By using optical systems that focus infrared radiation on the detector surfaces it should be possible to detect a variety of sources, such as star envelopes, interstellar dust, surfaces of plants, and other low temperature sources. The technique can be developed for interferometry with base lines of 100 to 1000 m, and for spectroscopic work using a tuned laser. (UK)

**23120** CONVECTION IN THE PRESENCE OF MAGNETIC FIELDS. Peckover, R. S. (United Kingdom Atomic Energy Authority, Abingdon, Eng.); Weiss, N. O. Comput. Phys. Commun.; 4: No. 3, 339-344(Dec 1972).

Convection driven by horizontal temperature gradients in an electrically conducting, viscous, Boussinesq fluid has been studied on a computer. Results of numerical experiments with a Grashof number of $10^4$ are presented and compared with linear theory. Weak magnetic fields are distorted and concentrated without significantly affecting the motion, while strong fields virtually suppress convection. For moderate fields there is a nonlinear regime in which the global magnetic and kinetic energies are comparable though the peak magnetic energy density may be an order of magnitude greater than the maximum energy density. The astrophysical relevance of these results is discussed. (auth)

**23121** ALPHA PARTICLES IN SOLAR COSMIC RAYS OVER THE LAST 80,000 YEARS. Lanzerotti, L. J. (Bell Telephone Labs., Murray Hill, NJ); Reedy, R. C.; Arnold, J. R. Science; 179: No. 4079, 1232-1234(23 Mar 1973).

Present-day (1967 to 1969) fluxes of alpha particles from solar cosmic rays, determined from satellite measurements, were used to calculate the production rates of cobalt-57, cobalt-58, and nickel-59 in lunar surface samples. Comparisons with the activities of nickel-59 (half-life $8 \times 10^4$ years) measured in lunar samples indicate that the long-term and present-day fluxes of solar alpha particles are comparable within a factor of approximately 4. (auth)

**23122** OBSERVING PROGRAMS IN SOLAR PHYSICS DURING THE 1973 ATM SKYLAB PROGRAM. Reeves, E. M.; Noyes, R. W.; Withbroe, G. L. (Harvard Coll. Observatory, Cambridge, MA). Solar Phys.; 27: No. 2, 251-270(Dec 1972).

One of the major scientific tasks of Skylab is to undertake an extensive series of solar observations using a cluster of x-ray, uv, and visible-light telescopes known as the Apollo Telescope Mount (ATM). The ATM and its capabilities, the principal scientific goals and the planned observing program, and methods of coordinating the observations with ground-based and other types of solar observations are described. (WDM)

**23123** SOLAR ROTATION AS DETERMINED FROM OSO-4 EUV SPECTROHELIOGRAMS. Dupree, A. K.; Henze, W. Jr. (Harvard Coll. Observatory, Cambridge, MA). Solar Phys.; 27: No. 2, 271-279(Dec 1972).

Spectroheliograms obtained in extreme ultraviolet (euv) lines and the Lyman continuum are used to determine the rotation rate of the solar chromosphere, transition region, and corona. A cross-correlation analysis of the observations indicates the presence of differential rotation through the chromosphere and transition region. The rotation rate does not vary with height. The average sidereal rotation rate is given by $\omega$ (deg day$^{-1}$) = 13.46 to 2.99 $\sin^2 B$ where B is the solar latitude. This rate agrees with spectroscopic determinations of the photospheric rotation rate, but is slower by ~1 deg day$^{-1}$ than rates determined from the apparent motion of photospheric magnetic fields and from the brightest points of active regions observed in the euv. The corona does not clearly show differential rotation as do the chromosphere and transition region. (auth)

**23124** FURTHER OBSERVATIONS OF THE SOLAR LIMB SPECTRUM IN THE REGION 550 TO 2000 A. Ridgeley, A.; Burton, W. M. (Culham Lab., Abingdon, Eng.). Solar Phys.; 27: No. 2, 280-285(Dec 1972).

Further observations of the ultraviolet spectrum (550 to 2000 Å) of the solar limb and disc were obtained during a Skylark rocket flight on August 5, 1971. These observations have enabled several new spectral lines to be identified and classified. (auth)

**23125** SOLAR ISOTOPIC COMPOSITION AND ABUNDANCE OF EUROPIUM. Hauge, O. (Univ. of Oslo). Solar Phys.; 27: No. 2, 286-293(Dec 1972).

High-resolution spectra of six photospheric Eu II lines were studied using the method of spectrum synthesizing. The isotope ratio was found to be $Eu_{153}/Eu_{151} = (48 \pm 6)/(52 \mp 6)$ and the solar abundance of europium equals $\log \epsilon_{Eu} = 0.7 \pm 0.2$ in the $\log \epsilon_H = 12.00$ scale. (auth)

**23126** SOLAR MANGANESE ABUNDANCE. Margrave, T. E. Jr. (Univ. of Montana, Missoula). Solar Phys.; 27: No. 2, 294-298(Dec 1972).

A preliminary solar Mn abundance of log N(Mn) = 5.41 (log N(H) = 12.00) is derived on the basis of fitting theoretical line profiles which include hyperfine structure (HFS) broadening to the profiles of the $\lambda\lambda$5394.7, 5432.6, and 5537.8 lines of Mn observed at the center of the solar disk with the double-pass spectrograph of the McMath solar telescope at Kitt Peak. Both the Mn abundance and the collisional damping constant were varied during the fitting procedure in order to minimize the rms deviation between the observed and computed profiles. (auth)

**23127** OBSERVED ODDITIES IN THE LINES H, K, b, AND H$\beta$. Evans, J. W.; Catalano, C. P. (Air Force Cambridge Research Labs., Sunspot, NM). Solar Phys.; 27: No. 2, 299-302 (Dec 1972).

Microphotometer intensity traces perpendicular to dispersion in simultaneous spectrograms of good spatial resolution traced at various $\Delta\lambda$'s in each of the lines were compared. Cross correlations between the different traces showed the following: (a) For each $\Delta\lambda_K$ there is a corresponding $\Delta\lambda_{b_1}$ at which the coefficient of correlation, r, is a maximum, usually >0.8. (b) No such high correlations are found between H and H$\beta$. (c) Comparison of traces in the continuum and at all observed $\Delta\lambda$'s in K, H, $b_1$, $b_2$ show a range of $\Delta\lambda$'s in each line over which r is very significantly negative, while H$\beta$ shows no such peculiarity. (auth)

**23128** INTERPRETATION OF THE CORRELATIONS IN INTENSITY FLUCTUATIONS IN THE LINES Ca II, H AND K, MAGNESIUM b, AND HYDROGEN H$\beta$. Thomas, R. N. (Joint Inst. for Lab. Astrophysics, Boulder, CO). Solar Phys.; 27: No. 2, 303-304.

In the preceding note, Evans and Catalano found interesting behavior in the correlation between intensity fluctuations in the continuum and in the lines H and K of Ca II, $b_1$ and $b_2$ of Mg I, and hydrogen H$\beta$. In the first four lines, the correlation drops smoothly from ~0.9 near the continuum to negative values; followed by a rise to about zero at line center. For H$\beta$, the correlation is never negative, reaching zero at about 0.25 Å. It is suggested that this behavior reflects a combination of effects. First, the source−sink terms in the source-functions depend on different physical parameters in the two sets of lines. In addition, the line center regions are dominated by transfer effects at the top of the atmosphere. (WDM)

**23129** QUANTUM THEORY OF LINE FORMATION IN A MAGNETIC FIELD. Landi Degl'Innocenti, E.; Landi Degl'Innocenti, M. (Astrophysical Observatory of Arcetri, Florence). Solar Phys.; 27: No. 2, 319-329(Dec 1972).

The transfer equations for the Stokes parameters in the presence of magnetic field and under the hypothesis of LTE are derived in an original way by the use of density matrix techniques. The results are substantially the same as those previously obtained by other authors. The results are compared to the previous ones in order to clarify some discrepancies still present in the literature. (auth)

**23130** SMALL-SCALE STRUCTURE OF SOLAR MAGNETIC FIELDS. Frazier, E. N. (San Fernando Observatory, El Segundo, CA); Stenflo, J. O. Solar Phys.; 27: No. 2, 330-346 (Dec 1972).

The small-scale structure of solar magnetic fields has been studied using simultaneous recordings in the spectral lines Fe I 5250 Å and Fe I 5233 Å, obtained with the Kitt Peak multi-channel magnetograph. It is found that more than 90% of the magnetic flux in active regions (excluding the sunspots), observed with a 2.4 by 2.4″ aperture, is channelled through narrow filaments. This percentage is even higher in quiet areas. The field lines in a magnetic filament diverge rapidly with height, and part of the flux returns back to the neighboring photosphere. Therefore the strong fields within a magnetic filament are surrounded by weak fields of the order of a few gauss of the opposite polarity. The field-strength distribution within a filament, including the surrounding opposite-polarity fields, seems to be almost the same for all filaments within a given active or quiet region. The analysis of a scan made during an imp. 2 flare showed that observations during and after the flare would give a fictitious decrease of the magnetic energy in the region by a factor of 2 to 3 due to line-profile changes during the flare. (auth)

**23131** ULTRAVIOLET CHAMBER MEASUREMENTS OF THE SOLAR MINIMUM BRIGHTNESS TEMPERATURE. Carver, J. H. (Univ. of Adelaide); Horton, B. H.; Lockey, G. W. A.; Rofe, B. Solar Phys.; 27: No. 2, 347-353(Dec 1972).

The solar ultraviolet flux in the wavelength bands 1580 to 1640 Å and 1430 to 1470 Å (FWHM) was measured using photon ion chambers carried on the satellite WRESAT I (1967-118A). These observations of the integrated ultraviolet flux from the entire disk indicated a value of (4570 ± 50) K for the solar temperature minimum. The results were compared with other estimates of the minimum value of the solar brightness temperature. (auth)

**23132** COOLING OF A SUNSPOT. I. A Carnot Cycle and the Hydromagnetic Interactions. Wilson, P. R. (Univ. of Sydney). Solar Phys.; 27: No. 2, 345-362(Dec 1972).

A mechanism is proposed to explain the cooling of a sunspot in terms of the detailed interactions between the magnetic field and the convective motions. The mechanism provides that an axially symmetric concentration of magnetic field deforms the normal supergranule cell pattern below the sunspot into a radial outflow of plasma over a region of diameter ~60 Mm. The flow occurs at depths where the magnetic and kinetic energy densities are approximately equal (≈5 Mm) and is described in terms of a Carnot refrigeration cycle. Application of the hydromagnetic equations to a very simple model shows that, because the magnetic field concentration causes the outflow, the field will itself decay in a time short compared with the lifetime of a spot. However, a slightly more sophisticated model does suggest conditions under which this decay is considerably reduced. Observations of the outward drift of magnetic knots around sunspots and of supergranule-type surface motions extending radially outwards from the penumbra of a spot to the nearest faculae are discussed in relation to the mechanism. (auth)

**23133** COOLING OF A SUNSPOT. II. Convection Zone Models and the Magnetic Power Supply. Wilson, P. R. (Univ. of Sydney). Solar Phys.; 27: No. 2, 363-372(Dec 1972).

In order to discuss the detailed interactions between the magnetic and velocity fields below a sunspot, several models of the convection zone are considered. It is suggested that giant convection cells establish a pattern of large superadiabatic gradients near the top and bottom of the zone analogous with the temperature gradients in laboratory convection. These gradients in turn establish their own eddies or cells with dimensions typical of the local scale height. Those at the top correspond to the photospheric granules while overshoot motions from the bottom of the layer may be related to the surface supergranule motions. The possibility that the surface supergranule motions are due to a counter-cell lying above a thermally driven supergranule cell is discussed and this concept is included in one of the models which may be typical of quiet regions of the convection zone. However, it is suggested that just prior to the appearance of a sunspot, overshoot motions from the deep eddy may extend almost to the top of the convection zone replacing the counter-cell by the motions of the cooling cycle discussed in paper I. The magnetic power required by this cycle may be supplied by the upward drift of flux ropes expelled from and amplified by these elongated convection eddies. For a typical sunspot, an upper limit to the power required is $9 \times 10^2 \text{ erg s}^{-1}$. Consideration of all forms of energy emitted from a sunspot and its immediate neighborhood (including hydromagnetic waves and excess facular radiation) fails to account for $1.1 \times 10^2 \text{ erg s}^{-1}$ of the flux normally emitted through an equivalent area of the photosphere. Thus if this thermal and kinetic energy is converted to magnetic energy by the expulsion of flux from the convective eddies, the magnetic power requirements of the cooling mechanism may be readily satisfied. (auth)

**23134** ENERGY BALANCE IN THE CHROMOSPHERE–CORONA TRANSITION REGION. Kopp, R. A. (National Center for Atmospheric Research, Boulder, CO). Solar Phys.; 27: No. 2, 373-393(Dec 1972).

The classical picture of the transition region is that of a thin spherically symmetric shell maintained in a steady average thermodynamical state by a balance between conductive heating from the hot overlying corona and radiative losses. The further analysis of existing extreme ultraviolet flux data casts doubt on the correctness of this simple model. It is shown that the downward heat flux between the chromosphere and corona cannot be nearly as large as the value $6 \times 10^5 \text{ erg cm}^{-2} \text{ s}^{-1}$ derived in previous studies by assuming a planar atmosphere, and in fact is insufficient to balance transition-region radiative losses. An alternative picture is developed, consisting of a "transition region network" covering only a small fraction of the solar disk. The dissipation of mechanical energy, previously neglected in many calculations of theoretical transition region models, appears to play a dominant role in the local energy balance of the network. (auth)

**23135** MODEL FOR THE POLAR TRANSITION LAYER AND CORONA FOR NOVEMBER 1967. Withbroe, G. L.; Wang, Y. M. (Harvard Coll. Observatory, Cambridge, MA). Solar Phys.; 27: No. 2, 394-401(Dec 1972).

A model for the chromospheric-coronal transition layer and lower corona was constructed for the south polar region. EUV observations acquired by the Harvard OSO-4 experiment in the fall of 1967 were used in the analysis. The observations can be explained with a simple model consisting of two types of regions. One region has a temperature–density structure similar to that in models developed for typical equatorial quiet areas. The other region has a corona in which the temperature and density are a factor of about 2 lower and the chromospheric-coronal temperature gradient is less steep by a factor of 4. (auth)

**23136** MODEL OF THE QUIET SOLAR ATMOSPHERE. Piddington, J. H. (National Standards Lab., Sydney). Solar Phys.; 27: No. 2, 402-419(Dec 1972).

The solar atmosphere may be divided into a number of isolated active components and a quiet residue. On the largest scale the latter is dominated by a general dipole magnetic field of strength 1 to 2 G; its observable components are flux concentrations in supergranule boundary regions (SBRs), spicules, mottles, and polar plumes. The velocity field in the SBRs is discussed. There are continuous gas streaming motions up and down between the photosphere and the corona; spicules may be mainly downward moving gas. A unifying model is developed of these various components, as well as the heating mechanism of the whole quiet atmosphere. Highly ordered velocity fields of the cell, together with a gravitational wave, cause a vertical magnetic force tube to collapse below a critical level; the result is an upward eruption of a vortex ring at the Alfvén velocity. The complex mass velocity pattern may explain spicules, mottles, and plumes, as well as unobservable streaming motions. The quiet atmosphere is divided into regions above SBRs and those above the inner parts of the cells. Hydromagnetic eruptions from the former may account for the entire heat requirement of the atmosphere. The model atmosphere has a chromosphere–corona transition layer which bulges upwards above the SBRs and so conforms with euv data. The energy and mass balances in this solar atmosphere are considered, and it is also shown to be consistent with the radio data. (auth)

**23137** CORE ELECTRON DENSITIES OF CORONAL POLAR PLUMES. Psujek, C. J.; Teske, R. G. (Univ. of Michigan, Ann Arbor). Solar Phys.; 27: No. 2, 420-425(Dec 1972).

The electron density in the cores of coronal plumes that is determined from observations will depend upon the assumed electron density distribution through the plume in a direction normal to its axis. Core electron densities obtained by Saito (1965) and by Newkirk and Harvey (1968) were derived using different assumed electron density profiles, and are not in agreement. Saito's data is re-discussed using Newkirk and Harvey's electron density profile and it is found that the disagreement persists. Whether this indicates a true variation in electron density in plume cores cannot now be stated. Errors in the electron densities derived may arise through errors in measuring the angles $\theta$ and $\alpha$ which enter into the analysis. While plausible variations in $\theta$ produce no appreciable errors in core electron density, plausible variations in $\alpha$ may introduce appreciable errors into the determinations of that quantity. (auth)

**23138** PRELIMINARY INTERPRETATION OF THE POLARIZATION MEASUREMENTS PERFORMED ON INTERCOSMOS-4 DURING THREE X-RAY SOLAR FLARES. Tindo, I. P. (Lebedev of Inst. of Physics, Moscow); Ivanov, V. D.; Valnicek, B.; Livshits, M. A. Solar Phys.; 27: No. 2, 426-435(Dec 1972).

Analysis of the x-ray polarization data at $\lambda \simeq 0.8$ Å for three major chromospheric flares shows that during the "hard" phase of the flare the x rays are polarized in the plane, the projection of which on the solar disc is going approximately from the flare region to the center of the disc. Simultaneously performed measurements of the spectral energy distribution have proved that observed x-rays are produced by the bremsstrahlung of the accelerated electrons with the energies in the range 10 to 100 keV. The experimental data are in good agreement with the flare model, which deals with the radial movement of accelerated electrons towards the photosphere, together with the continuous injection of these electrons into the emitting region. (auth)

**23139** SIMULATION OF THE DIRECTIVITY EFFECT TO BE EXPECTED IN HARD X-RAY FLARES. Shaw, M. L. (European Space Research and Tech. Centre, Noordwijk, Netherlands). Solar Phys.; 27: No. 2, 436-441(Dec 1972).

A Monte Carlo technique was used to predict the relative visibility of solar hard x-ray flares as a function of solar longitude assuming the model of Takakura and Kai to be realistic. Comparison was made with previous statistical studies of observations. A discernable longitudinal variation in the relative visibility of flares is shown to be expected but the probability of flares being visible towards the limb is shown to be higher than had previously been evident. The effect of the possible downward inclination of the particle beam with respect to the solar surface is considered. (auth)

**23140** LIFETIME OF SOLAR FLARE PARTICLES IN CORONAL STORAGE REGIONS. Anderson, K. A. (Univ. of California, Berkeley). Solar Phys.; 27: No. 2, 442-445(Dec 1972).

Most discussions of lifetime of flare particles in the solar corona have assumed that collision loss is the dominant means of slowing and stopping these particles. The customary formulas used to estimate the rate of collision loss assume individual fast particles interacting with relatively cold matter. However, it is quite possible that the solar cosmic rays are not imbedded in $10^6$ K coronal material but rather all particles in the storage region are energetic. Collision times are sufficiently short so that the energy spectrum may approach a Maxwellian distribution with kT on the order of 30 keV. If this is the case, the rate of collision loss will be greatly reduced. Bremsstrahlung and magnetobremsstrahlung then will be the important energy losses. To account for the presence of appreciable numbers of MeV particles, it is probably necessary to postulate the existence of a nonthermal tail in the stored particle distribution. (auth)

**23141** DIRECT OBSERVATIONS OF LOW-ENERGY SOLAR ELECTRONS ASSOCIATED WITH A TYPE III SOLAR RADIO BURST. Frank, L. A.; Gurnett, D. A. (Univ. of Iowa, Iowa City). Solar Phys.; 27: No. 2, 446-465(Dec 1972).

A highly anisotropic packet of solar electron intensities was observed on April 6, 1971 with a sensitive electrostatic analyzer array on IMP-6. The anisotropies of intensities at electron energies of several keV were factors $\gtrsim 10$ favoring the expected direction of the interplanetary magnetic lines of force from the Sun. The directional, differential intensities of solar electrons were determined over the energy range 1 to 40 keV and peak intensities were $\sim 10^2 \text{ cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \text{ eV}^{-1}$ at 2 to 6 keV. This anisotropic packet of solar electrons was detected at the satellite for a period of 4200 s and was soon followed by isotropic intensities for a relatively prolonged period. This impulsive emission was associated with the onsets of an optical flare, soft x-ray emission, and a radio noise storm at centimeter wavelengths on the western limb of the Sun. Simultaneous measurements of a Type III radio noise burst at kilometric wavelengths with a plasma wave instrument on the same satellite showed that the onsets for detectable noise levels ranged from 500 s at 178 kHz to 2700 s at 31.1 kHz. The corresponding drift rate requires a speed of ~0.15c for the exciting particles if the emission is at the electron plasma frequency. The corresponding electron energy of ~6 keV is in excellent agreement with the above direct observations of the anisotropic electron packet. Further supporting evidence that several-keV solar electrons in the anisotropic packet are associated with the emission of Type III radio noise beyond ~50 $R_\odot$ is provided by their time-of-arrival at Earth and the relative durations of the radio noise and the solar electron packet. Electron intensities at E $\gtrsim$ 45 keV and the isotropic intensities of lower-energy solar electrons are relatively uncorrelated with the measurements of Type III radio noise at these low frequencies. The implications of these observations relative to those at higher frequencies, and heliocentric radial distances $\lesssim$50 $R_\odot$, include apparent deceleration of the exciting electron beam with increasing heliocentric radial distance. (auth)

**23142** SHOCK WAVE EFFECTS IN SOLAR COSMIC RAY EVENTS. Palmer, I. D. (CSIRO, Sydney). Solar Phys.; 27: No. 2, 466-477(Dec 1972).

Two low-energy ($\lesssim$1 MeV) solar proton events which display a gradual intensity increase to a maximum near the time of an SSC, followed by an abrupt, large decrease, are interpreted in terms of a population of cosmic rays which are "swept" ahead of an interplanetary shock wave. A model which describes the variation with time of intensity and anisotropy at the Earth is developed using a Monte Carlo technique which traces the histories of particles released impulsively at the Sun. A good fit to each of the profiles observed at 0.6 to 0.9 MeV proton energies is obtained with a diffusion coefficient $\kappa \approx 2 \times 10^{20}$ cm$^2$ s$^{-1}$ and a near perfect shock reflector. (auth)

**23143** ASYMPTOTIC BEHAVIOR OF THE SUPERSONIC SOLUTIONS OF THE TWO-FLUID SOLAR-WIND EQUATIONS. Roxburgh, I. W. (National Center for Atmospheric Research, Boulder, CO). Solar Phys.; 27: No. 2, 478-480(Dec 1972).

Three different asymptotic branches of the two-fluid equations are found with $\tau_e \alpha \lambda^m$, $\tau_p \alpha \lambda^n$, where, $\lambda$ is the inverse distance from the Sun, with (m,n) = ($^2/_7$, $^2/_7$), ($^2/_7$, $^6/_7$), ($^4/_3$, $^4/_3$); other special solutions are also found but they correspond to special choices of density and temperature at the corona. In all the ($^4/_3$, $^4/_3$) solutions, the electron and proton temperatures tend to equality at large distances. (auth)

**23144** INSTRUMENTAL POLARIZATION CONCERNING MAGNETOGRAPHIC MEASUREMENTS. Jaeger, F. W. (Sonnenobservatorium Einsteinturm, Potsdam, Ger.). Solar Phys.; 27: No. 2, 481-488(Dec 1972).

It is shown in detail in which way magnetographic measurements may be affected by instrumental polarization. To eliminate this influence a combined method of partial compensation and computation is proposed practicable successfully with only a moderate expenditure of calculations and instrumental equipment. (auth)

**23145** THEORY OF WEAK SCREENING IN THERMONUCLEAR REACTIONS. Delano, M. D. (Yeshiva Univ., New York); Langer, W. D.; Schwartz, R. A. Astrophys. Lett.; 13: No. 2, 105-107 (Feb 1973).

The effects of screening of the Coulomb field on thermonuclear reaction rates in nondegenerate plasmas are calculated. It is found that in the screening factor $\exp(\Delta E/k_BT)$, $\Delta E$ is $^3/_2$ the Salpeter result. (auth)

**23146** EFFECTS OF SOLAR ACTIVITY ON ZONAL WINDS IN THE STRATOSPHERE AND LOWER MESOSPHERE. Kazimirovskii, E. S.; Loginov, V. F. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Novosibirsk, USSR). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 700-704 (1973).

Translated from Astron. Zh.; 49: No. 4, 860-865(1972).

Models of the E – W wind component corresponding to high and low solar activity have been derived from American Rocket Network data. The 10.7-cm radio flux and the planetary geomagnetic index Ap are adopted as activity indices. The wind variability associated with solar activity is greatest for the upper and middle stratosphere in high latitudes, primarily because of greater instability of the atmosphere rather than the solar activity itself. At most seasons the effects of the wave ($S_{10.7}$) and the corpuscular (Ap) energy influx are opposed. The observed relationships are interpreted and a procedure is suggested for selecting reference dates for analyses of atmospheric circulation. Several considerations are offered regarding the mechanism of solar–atmospheric relations. (auth)

**23147** BROOKHAVEN SOLAR NEUTRINO EXPERIMENT. Davis, R. Jr.; Evans, J. C.; Radeka, V.; Rogers, L. C. (Brookhaven National Lab., Upton, NY). pp 5-22 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

A solar neutrino experiment has been in progress since 1967 to observe neutrinos from the Sun by the neutrino capture reaction $^{37}$Cl(v,e$^-$)$^{37}$Ar. 380,000 liters of perchloroethylene, $C_2Cl_4$, are used as a neutrino capturing medium. The radioactive $^{37}$Ar(35.1-day half-life) is removed from the liquid by purging with helium gas, purified, and counted in a small low-level proportional counter. Argon-37 decay events are characterized by the energy of the event and the rise-time of the counter pulse. The results of six experiments performed during the last two years are given. The $^{37}$Ar production rate in the detector was 0.18 ± 0.10 per day, close to the production rate expected from cosmic-ray muons. The experiment places an upper limit on the production of $^{37}$Ar by solar neutrinos of $1 \times 10^{-36}$ sec$^{-1}$($^{37}$Cl atom)$^{-1}$. This limit can be compared to the currently predicted rate of $9 \times 10^{-36}$ sec$^{-1}$ ($^{37}$Cl atom)$^{-1}$ from solar-model calculations of Bahcall and Ulrich, and Abraham and Iben. (auth)

**23148** ARE THE SOLAR-NEUTRINO EXPERIMENTS SUGGESTIVE OF THE EXISTENCE OF A RESONANCE IN THE $^3$He + $^3$He SYSTEM. Fetisov, V. N.; (Lebedev Physical Inst., Moscow); Kopysov, Yu. S. pp 23-27 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol. 1).

The discrepancy existing between the Davis value and the theoretical value for the counting rate of solar neutrinos suggests perhaps a resonance in the $^3$He($^3$He,2p)$^4$He reaction. This possibility is briefly examined. (WDM)

**23149** SOLAR NEUTRINOS: THEORY. Bahcall, J. N. (Inst. for Advanced Study, Princeton, NJ). pp 29-75 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol. 1).

The origin of the discrepancy between the Brookhaven experiment and theoretical calculations is reviewed in an attempt to illustrate what is being tested and how. Cross sections and solar models are reviewed and consideration is given to the questions of whether or not solar neutrinos reach the Earth and on what should be done next to understand the origin of the discrepancy between theory and experiment. (WDM)

**23150** BACKGROUND EFFECTS IN THE SOLAR NEUTRINO EXPERIMENT. Davis, R. Jr. (Brookhaven National Lab., Upton, NY); Wolfendale, A. W.; Young, E. C. M. pp 77-84 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol. 1).

The background effects in the solar neutrino experiment are investigated. The expected rate of $^{37}$Ar production by cosmic-ray muons as a function of depth underground is calculated and compared with measured values at shallow depths. The muon background at the main detector at 4,400 m.w.e. is then estimated. The expected background from cosmic-ray neutrinos is also estimated. It is shown that upper limits to the photonuclear cross section up to energies ~150 GeV can be derived from this estimate. (auth)

**23151** INVESTIGATION OF THE BACKGROUND IN THE SOLAR NEUTRINO PROPORTIONAL COUNTERS. Barabanov, I. R.; Pomanskii, A. A. (Inst. of Nuclear Research, Moscow). pp 85-86 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol. 1).

The contributions to the background in the solar neutrino proportional counters due to radioactive contamination of the counter material, gamma radiation of radioactive isotopes present in the laboratory environment, and cosmic radiation are briefly discussed. (WDM)

**23152** NEW APPROACHES TO THE SOLAR NEUTRINO PUZZLE. Lande, K. (Univ. of Pennsylvania, Philadelphia); Bozoki, G.; Lee, C. K.; Fenyves, E. pp 87-97 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol. 1).

Two classes of suggestions for explaining the puzzle of the missing solar neutrinos are discussed. One suggests that the solar neutrino production rate is time dependent and the other proposes changes in neutrino character in the interval between production in the Sun and arrival at the Earth so that the solar neutrino no longer behaves like a $\nu_e$ at the Earth. (WDM)

**23153** REMARK ON STABILITY OF ANTI $\nu_e$. Reines, F. (Univ. of California, Irvine). p 137 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol. 1).

The possibility that $\bar{\nu}_e$ is unstable is briefly discussed and the $\bar{\nu}_e \rightarrow \bar{\nu} + \gamma$ is ruled out as a decay mode. (WDM)

**23154** CORPUSCULAR RADIATION AND ACTIVE PROMINENCES. Kleczek, J. (Astronomical Inst., Ondrejov, Czech.). Izv. Akad. Nauk SSSR, Ser. Fiz., 36: No. 11, 2278-2280(Nov 1972). (In Russian).

A brief survey is given of the phenomena associated with solar flares. Emphasis is placed on the connection between active prominences and various types of corpuscular radiation which appear to be cosmic in origin. (KSW)

**23155** PROPAGATION OF SOLAR COSMIC RAYS IN THE INTERPLANETARY MEDIUM. Lyubimov, G. P.; Pereslegina, N. V.; Kontor, N. N. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2297-2305(Nov 1972). (In Russian).

The role of concentrated large-scale inhomogeneity of a magnetized interplanetary plasma which is injected by solar flares was examined. Experimental observations were made of diffusion, convection, inclination, and acceleration of solar cosmic rays during their propagation from the Sun. (tr-auth)

**23156** ISOTOPIC COMPOSITION OF He IN SOLAR CORPUSCULAR FLUXES. Boltenkov, B. S.; Gartmanov, V. N.; Kocharov, G. E.; Naidenov, V. O.; Starbunov, Yu. N. (Ioffe Inst. of Physics and Tech., Leningrad). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2319-2323(Nov 1972). (In Russian).

A number of the data taken aboard various artificial satellites on the content of He isotopes in solar corpuscular streams was reviewed and tabulated, the data originating in the chromosphere, solar flares, and the solar wind. The largest ratio of $^4$He/$^3$He was recorded in achondrites, which presumably represents the isotopic composition of the solar wind at an early epoch. The present-day coronal content of $^3$He is greater than in the early Sun; three causes of this are discussed: nuclear reactions in the solar atmosphere, a flow of $^3$He from the interior of the Sun, and the formation of $^3$He in subphotospheric layers. (KSW)

**23157** SUDDEN INCREASE IN INTENSITY OF COSMIC RAYS IN 1970 TO 1971 ACCORDING TO STRATOSPHERIC MEASUREMENTS. Charakhch'yan, A. N.; Bazilevskaya, G. A.; Vashenyuk, E. V.; Petrova, G. L.; Stozhkov, Yu. I.; Khor'kov, V. D.; Charakhch'yan, T. N. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2363-2368(Nov 1972). (In Russian).

The energy spectra and time dependence of fluxes of solar protons were recorded in the stratosphere March 29, 1970, January 24, 1971, and September 1, 1971. In the first of these a sudden increase in intensity was observed with a protracted maximum in the solar neutron flux up to $E_p \geq 200$ MeV lasting more than 10 hr. An unusual increase in the hardness in the integral spectrum of solar protons with energies 100 to 400 MeV was noted in the flare of January 24, 1971. (tr-auth)

**23158** ENERGY SPECTRA OF SOLAR PROTONS FROM STRATOSPHERIC MEASUREMENTS. Bazilevskaya, G. A.; Stozhkov, Yu. I.; Charakhch'yan, A. N.; Charakhch'yan, T. N. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2369-2375(Nov 1972). (In Russian).

Spectra from the generation of solar protons were determined for a series of flares of the 19th and 20th cycles of solar activity within the framework of an isotropic diffusion model. The approximation of spectra for the generation of exponential functions from the kinetic energy or hardness of particles was unsatisfactory if the energy range was sufficiently large (10 to 500 MeV). At the same time, an approximation of the degree of the functions from the energy or hardness was a good approximation for all flares considered. The number of particles and the energy generated in the flares were calculated. (tr-auth)

**23159** RELATIONSHIP OF THE 27-DAY VARIATIONS IN COSMIC RAYS TO THE DIFFERENT INDICES OF SOLAR ACTIVITY FOR THE PERIOD 1957 TO 1970. Bazilevskaya, G. A.; Okhlopkov, V. P.; Charakhch'yan, T. N. (Lebedev Inst. of Physics, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2376-2382(Nov 1972). (In Russian).

In investigation of the connection between the 27-day intensity cycle of cosmic rays and a series of solar activity indices showed that the amplitude of both the former and the latter is extremely unstable; frequently the important changes occurred over short time intervals. If the Forbush effects are excluded, then it is possible to completely explain the 27-day variation in cosmic rays with amplitude greater than 0.5% (according to neutron monitor data) by the action on cosmic rays of plasma fluxes from active regions. The time of delayed variations in cosmic rays relative to solar activity consisted of 1 to 3 months. (tr-auth)

**23160** KINETIC TEMPERATURE OF He$^{++}$ IN THE SOLAR WIND. Barnes, A.; Hung, R. J. (Ames Research Center, Moffett Field, CA). Cosmic Electrodyn.; 3: No. 4, 416-436(Jan 1973).

Several processes are discussed which may influence the temperature of He$^{++}$ in the solar wind, and whether they can account for the observations that $T_{He} \sim 4\ T_p$ is considered. The suggestion that $T_{He}$ is determined predominantly by hydromagnetic-wave dissipation has a number of difficulties, and would require special conditions in the region of transition from collisional to collisionless solar-wind flow. Preferential heating of helium by nonhydromagnetic modes may be required to raise $T_{He}$ above $T_p$ enough that hydromagnetic-wave dissipation would preferentially raise $T_{He}$. Another process that might tend to make $T_{He} \sim 4\ T_p$ is pitch-angle scattering of He and protons in colliding streams. Other aspects of collisionless flow may also have to be considered to understand why $T_{He} \sim 4\ T_p$. (auth)

**23161** MODULATION OF GALACTIC COSMIC RAYS BY THE NONSPHERICAL-SYMMETRICAL SOLAR WIND ALLOWING FOR ANISOTROPIC CONDITIONS IN THE VICINITY OF THE SUN. Dorman, L. I.; Kobilinski, Z. Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2332-2345(Nov 1972). (In Russian).

A model was examined which considered the presence of two regions of solar wind with anisotropic diffusion in the vicinity of the Sun, and isotropic diffusion at great distances from the Sun. For a determination of the modulated effects, among which were a solar wind nonuniform with respect to latitude and longitude, an equation for anisotropic diffusion was solved, allowing for convection and deceleration of particles by an anti-Fermi mechanism. The anticipated distribution of cosmic-ray density in space was found, and the amplitude of the 27-day variation in cosmic rays and the gradient of cosmic radiation were evaluated. (tr-auth)

**23162** COSMIC RAY FLUX AND STRUCTURAL FORMATION IN THE SOLAR WIND. Altukhov, A. M.; Krymskii, G. F.; Kuz'min, A. I.; Skripin, G. F.; Transkii, I. A. (Inst. of Cosmophysical Research and Air Sciences, Yakutsk, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2285-2291(Nov 1972). (In Russian).

Abrupt changes in the direction of the flux of cosmic rays were associated with the passage of the Earth through structural formations in the solar wind. Two types of flux structures were noted, connected with the incidence and arrival on the Earth from a region of fast solar wind. Structures not related to these types were characterized differently; a third type of structure did not find an explanation in simple models of the solar wind. (tr-auth)

**23163** PARTICLE SCATTERING IN INTERPLANETARY SPACE AND THE PROPERTIES OF SOLAR CORPUSCULAR FLUXES. Toptygin, I. N. (Leningrad Polytechnic Inst.). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2258-2264(Nov 1972). (In Russian).

The anisotropic distribution of solar protons was analyzed on the basis of nonsteady state solutions of the kinetic equation. Conditions for the stability of fluxes of energetic electrons and protons were examined relative to the buildup of Langmuir and Al'venov waves. A Green function of a stationary equation of particle transfer in interplanetary space was constructed for a random dependence of the diffusion coefficient on energy. The transformation of the particle spectrum was considered. (tr-auth)

**23164** TEMPERATURE DISTRIBUTION IN AN IRREGULARITY IN RADIATIVE EQUILIBRIUM. Dashevskii, V. M.; Obridko, V. N. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 651-654(1973).

Translated from Astron. Zh.; 49: No. 4, 796-801(1972).

The problem of radiative equilibrium in a cylinder surrounded by a medium with an arbitrary temperature distribution is analyzed. An analytic solution is obtained for an absorption coefficient depending linearly on optical depth. The solution is applied to the problem of the temperature distribution in a photospheric column located within a sunspot umbra and supplied with energy from below. (auth)

**23165** ENERGY BALANCE IN THE CURRENT SHEET OF A SOLAR FLARE, AND THE ACCELERATION OF COSMIC RAYS BY PLASMA WAVES. Tomozov, V. M. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 655-661 (1973).

Translated from Astron. Zh.; 49: No. 4, 802-811(1972).

The energy balance and acceleration of electrons by plasma waves in a solar-flare current sheet are considered in terms of the model proposed by Syrovatskii. When ionosonic turbulence develops in the sheet through the two-stream instability induced by runaway electrons, Langmuir plasmons will be generated, accelerating the resonance electrons to relativistic energies in the range from 5 MeV to 1 BeV. The relativistic electrons escaping from the current sheet should have a spectrum of the form $f_\epsilon \sim \epsilon^2 \exp(-\epsilon/\epsilon_0)$ for $\epsilon > \epsilon_0$. (auth)

**23166** NONTHERMAL X RAYS AND ELECTRIC CURRENTS IN SOLAR FLARES. Vil'koviskii, E. Ya.; Kozhanov, T. S. (Astrophysical Inst., Alma-Ata, USSR). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 662-665(1973).

Translated from Astron. Zh.; 49: No. 4, 812-816(1972).

X-ray flare spectra were computed for the electric-current mechanism of particle acceleration. A comparison with observations showed that the model is applicable for explaining the first phase in flare events. (auth)

**23167** ORIGIN OF CHAINS OF TYPE I SOLAR RADIO BURSTS. Zaitsev, V. V.; Fomichev, V. V. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 666-673(1973).

Translated from Astron. Zh.; 49: No. 4, 817-826(1972).

A discussion is given of a mechanism for generating chains of Type I radio bursts by ($M < 1.5$) collisionless shock waves in plasma with a strong magnetic field ($\omega_H \geq \omega_L$, where $\omega_H$, $\omega_L$ are the gyrofrequency and Langmuir frequency of the electrons). The mechanism can satisfactorily explain many of the observed properties of Type I chains (frequency drift, splitting, bandwidth of individual chain components, polarization). From empirical data on chains the magnetic-field distribution and shock-wave parameters are calculated in the height range $(0.25 \text{ to } 1.5) \cdot 10^6$ km above the photosphere. Estimates are obtained for the size of irregularities in the solar corona. (auth)

**23168** POLARIZATION OF THE INNER CORONA AT THE TOTAL ECLIPSE OF MARCH 7, 1970. Sazanov, A. A. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 674-677(1973).

Translated from Astron. Zh.; 49: No. 4, 827-832(1972).

The inner corona was photographed through a polarizer in three position angles during the 1970 eclipse at Miahuatlan, Mexico. The filter–plate combination restricted the wavelength range to 5000 to 7000 Å. Equidensity curves were derived and isophotes corrected for instrumental polarization prepared for the three orientations. The percentage polarization at heights (0.1 to 0.5) $R_\odot$ above the limb was computed from the isophotes. In some places the polarization reached 1.3 to 1.5 times the maximum theoretical value. Its direction was nearly tangential. (auth)

**23169** KELVIN–HELMHOLTZ INSTABILITY IN TYPE I COMET TAILS. Ershkovich, A. I.; Nusinov, A. A.; Chernikov, A. A. (Inst. for Space Research, Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 705-708(1973).

Translated from Astron. Zh.; 49: No. 4, 866-871(1972).

The development of Kelvin–Helmholtz magnetohydrodynamic instability in comet tails is discussed. The tail is modeled as a plasma cylinder (with its free boundary a surface of tangential discontinuity) embedded in the interplanetary plasma. A criterion is obtained for the onset of instability, and the growth rate of magnetohydrodynamic waves in the tail is determined. This model provides at least a qualitative interpretation of several observed effects, such as helix-shaped tails and the rise in wave amplitude with distance from the comet head. (auth)

## Galaxies

**23170** (N–72–31868) MODEL OF THE LOCAL REGION OF THE GALAXY. Novaco, J. C.; Vandenberg, N. R. (National Aeronautics and Space Administration, Greenbelt, Md. Goddard Space Flight Center). Sep 1972. 20p. (NASA-TM-X-66011; X–693–72–8). NTIS.

A two-component model of the local interstellar medium was developed, based on the Radio Astronomy Explorer (RAE-1) satellite observations of the low frequency (0.2 to 10 MHz) galactic radio background spectrum. The model shows evidence for a thick spiral arm and a thick electron disk of 600 and 1200 pc slab thicknesses, respectively. The temperature difference between the north galactic pole and anticenter directions supports the concept of a local positive thermal gradient away from the galactic plane. A preliminary discussion of the influence of the Razin effect on the model is also presented. (auth)

**23171** PHOTON REST MASS AND ELECTRIC CURRENTS IN THE GALAXY. Byrne, J. C.; Burman, R. R. (Western Australia Univ., Nedlands). J. Phys., A (London); 6: No. 2, L12-L14(Feb 1973).

Following an idea of Goldhaber and Nieto (Phys. Rev. Lett.; 21: 567-9 (1968)), conditions for the existence and stability of the currents which are required to support the observed galactic magnetic field are used to obtain an upper limit for the photon rest mass. (auth)

**23172** OPTICAL AMPLITUDES AND RADIO SPECTRA OF VARIABLE GALAXIES. Hall, D. L.; Usher, P. D. (Pennsylvania State Univ., University Park). Nature (London) Phys. Sci.; 241: No. 106, 31-32(8 Jan 1973).

It has been proposed that the compact galaxy I Zw 187 (1727 + 50) be placed in a class of objects like BL Lacertae known as "lacertids". A major feature of this class is the extremely large total range of optical variability, and an examination of the optical records of I Zw 187 indicates a total optical amplitude of at least 2.1 blue photographic magnitudes, which places the object within the range of variability of the other proposed members of the class. There is also a suggestion of an empirical relationship between optical amplitude and radial spectral index for members of the class, in that more inverted radio spectra are associated with larger total optical amplitudes. The optical amplitudes for I ZW 187 and other members of the proposed class of lacertids are listed, together with the mean magnitudes of the maximum and minimum excursions. The brightest recorded magnitude was 14.8, and the total range of optical variability was at least 2.1 mag., and the amplitudes are all amongst the largest known for QSOs and compact galaxies. (UK)

**23173** LUMINOSITY FUNCTIONS OF CLUSTERS OF GALAXIES. Rood, H. J. (Michigan State Univ., East Lansing); Abell, G. O. Astrophys. Lett.; 13: No. 2, 69-72(Feb 1973).

Magnitudes determined independently by Abell and by Rood for galaxies in a 0.32 sq deg core region of the Coma Cluster are found to be in good agreement with each other. At the 100% completeness limit of Rood's sample, Abell's data are 91% complete by number and 97.5% complete by luminosity. Cluster luminosity functions display a prominent plateau near the bright end. (auth)

**23174** SUPERNOVA REMNANTS AND GAMMA-RAY SOURCES. De Freitas Pacheco, J. A. (Univ., Sao Paulo, Brazil). Astrophys. Lett.; 13: No. 2, 97-101(Feb 1973).

It is shown that, when evolutionary effects are taken into account, it is very difficult to explain the $\gamma$-ray galactic background flux by the pion decay mechanism in supernova remnants, unless current ideas on the energetics of supernovae are drastically changed. (auth)

**23175** PROPERTIES OF H I REGIONS HEATED BY X RAYS AND COSMIC RAYS. Bochkarev, N. G. (Astronomical Inst., Moscow). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 619-627 (1973).

Translated from Astron. Zh.; 49: No. 4, 756-767(1972).

The equilibrium conditions in an interstellar medium heated and ionized either by soft x rays having a power-law spectrum with a low-energy cutoff or by subcosmic rays of energy 2 MeV/N are compared by numerical solution of the equations of thermal balance and hydrogen/helium ionization equilibrium. It is found nearly impossible to distinguish the two cases from the equilibrium densities and temperatures of clouds and the intercloud medium. The most significant property of x-ray ionization is that helium is more highly ionized than hydrogen, unlike the cosmic-ray case. The parameters most stable against variations in the heating conditions, as well as in the heavy-element abundances, are the maximum possible (equilibrium) cloud temperature $T_c \approx 400$°K and the minimum possible intercloud temperature $T_i \approx 7000$°K. Two-component models of the interstellar medium with and between the spiral arms are constructed for various heating conditions. With an equilibrium model the observed low density $n_c = 4$ cm$^{-3}$ and low temperature $T_c = 60$°K of the clouds cannot be reconciled with the high mean electron density $\bar{n}_e = 0.03$ cm$^{-3}$ in the galactic disk inferred from pulsar data. There appears to be no evidence for depletion of heavy elements in the interstellar medium. Probably the medium is heated mainly by cosmic rays rather than x rays. For all reasonable models $T_i >$ 10,000°K. The ionization zones formed around pulsars in supernova outbursts may occupy some tens of percent of the volume of the galactic disk of $n_e \approx 0.1$ cm$^{-3}$ in the zones. Evidence from old pulsars indicates that $\bar{n}_e \approx 0.02$ cm$^{-3}$ in portions of the spiral arms undisturbed by these ionization zones. (auth)

**23176** H$\alpha$ EMISSION IN THE CENTRAL REGIONS OF NEARBY GALAXIES. Pronik, I. I. (Crimean Astrophysical Observatory, Simferopol, USSR). Sov. Astron. AJ (Engl. Transl.); 16: No. 4, 628-635(1973).

Translated from Astron. Zh.; 49: No. 4, 768-776(1972).

Spectra of the central regions of 16 nearby normal galaxies at 380 Å/mm dispersion were obtained at the prime focus of the 2.6-m reflector. The equivalent widths $W_{H\alpha}$ of the $H_\alpha$ emission line were measured. A correlation was found between $W_{H\alpha}$ and the blue color index in Tifft's photometric system; it could result from excitation of H$_\alpha$ emission by the ultraviolet radiation of blue stars. Calculations show that the number of stars required to excite H$_\alpha$ in the central regions of different galaxies is uniquely related to the color index of the region. The spectroscopic peculiarities of Seyfert-galaxy nuclear regions might be associated with the normal evolution of late-type giants through the phase of planetary-nebula nuclei. (auth)

## Cosmology

**23177** CPT CONSERVATION IN THE OSCILLATING MODEL OF THE UNIVERSE. Albrow, M. G. (European Organization for Nuclear Research, Geneva). Nature (London) Phys. Sci.; 241: No. 107, 56-57(15 Jan 1973).

Reference is made to Davies (Nature Phys. Sci. 240:3 (1972)) who proposed an oscillating model of the Universe in which the direction of time flow reverses between alternate cycles. The present author makes the hypothesis that CPT is vigorously conserved, where C is charge conjugation, P is parity, and T is time reversal. It is known experimentally that C and P are maximally violated in weak interactions and that CP and T are violated in weak interactions at a level of the order of $10^{-3}$, but despite careful searches no evidence has been found for violation of the combined symmetry operation CPT. A picture of the Universe is presented in terms of matter and antimatter. This simple picture gives complete symmetry between matter and antimatter, even if the observable Universe is primarily of one type. The model is reminiscent of the fluctuations of the vacuum in quantum electrodynamics, in which a virtual particle–antiparticle pair appears in free space and then annihilates. The author sees no testable observational consequences of the model, but believes it to form a viable and interesting basis for further investigation. A possible line of enquiry is the testing of "absolute" conservation laws at extremely high energy densities. In this connection the CERN Intersecting Storage Rings produce densities up to the order of $10^{17}$ g/cm$^3$, comparable with densities prevailing in the early Universe. It seems correct to assume that charge, baryon number, etc. are conserved throughout. (UK)

**23178** BLACK HOLES IN AN EXPANDING UNIVERSE. Demianski, M. (Univ., Warsaw); Lasota, J. P. Nature (London). Phys. Sci.; 241: No. 107, 53-55(15 Jan 1973).

The question of gravitational collapse to a black hole is treated in the context of an expanding universe. (auth)

**23179** LIMIT ON THE REDSHIFT DUE TO INTERACTION WITH ELECTROMAGNETIC RADIATION. Cohen, R. L.; Wertheim, G. K. (Bell Telephone Labs., Murray Hill, N. J.). Nature (London); 241: No. 5385, 109(12 Jan 1973).

Comments are offered on the communication of Pecker in Nature 237; 227(1972), discussing the possibility that part of the "cosmological" redshift could result from the interaction of photons with an interstellar radiation field. Although this suggestion is old it has recently regained prominence with the discovery of the 3K blackbody radiation. Pecker suggested some relevant experimental work involving measuring the energy loss of $\gamma$ rays traversing a laser beam by the Mossbauer effect, but this is very difficult to perform. Another Mossbauer experiment, however, is suggested in which $\gamma$ rays are propagated through a microwave cavity filled with photons. (UK)

**23180** PLASMA PROCESSES IN THE UNIVERSE. Kaplan, S. A. (NIFRI, Gorky, USSR); Tsytovich, V. N. Phys. Rep.; 7C: No. 1, 1-33(Feb 1973).

The role played by collective plasma processes in generating electromagnetic radiation and in accelerating relativistic particles in astrophysical objects such as galactic nuclei, quasars, or pulsars is discussed. Simple, order-of-magnitude relations are given which enable one to estimate the parameters of the plasma processes under cosmic conditions. Special attention is given to a plasma with an admixture of ultra-relativistic particles and to a fully relativistic plasma. An illustration is given—and without any pretensions to a complete discussion—concrete applications of the relations obtained for the appropriate astrophysical objects. (auth)

**23181** RELATION OF THE REDSHIFTS OF RADIO SOURCES TO THEIR ANGULAR DIAMETERS. Richter, G. M. (Zentralinstitut fuer Astrophysik, Babelsberg, Ger.). Astrophys. Lett.; 13: No. 2, 63-64(Feb 1973).

The observed angular diameter–redshift distribution for radio sources is shown to be in good agreement with the predictions from the Ryle–Longair concept for the evolution of individual radio sources. (auth)

**23182** LEPTON CHARGE CONSERVATION. Marx, G. (Roland Eoetvoes Univ., Budapest). pp 123-133 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

After a brief review of the different definitions for the leptonic charge the experimental accuracy of the conservation laws is given. The hypothetical milliweak or superweak violation of the conservation law is discussed. The dependence of the strength of the superweak charge asymmetry on cosmological time is suggested, its astronomical consequences are considered. (auth)

**23183** LEPTON ERA OF THE BIG BANG. de Graaf, T. (Univ. of Groningen, Netherlands). pp 167-189 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

During the lepton era in the early Universe the temperature decreases from $1.7 \times 10^{12}$ K to $5.9 \times 10^9$ K where the electrons annihilate. This corresponds to expansion times between $4 \times 10^{-5}$ and 3 sec and to densities between $3 \times 10^{14}$ and $5 \times 10^4$ gm/cm$^3$. Neutrino decoupling during the lepton era is considered along with cosmological nucleosynthesis and parameters of the hot big bang. (WDM)

**23184** COSMOLOGICAL LIMIT ON NEUTRETTO MASS. Marx, G.; Szalay, A. S. (Roland Eoetvoes Univ., Budapest). pp 191-195 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

By making use of the general relativistic cosmology, the rest mass of the muon neutrino could be obtained if the Hubble constant, the deceleration parameter, and the photon temperature were accurately known. In this note the decoupling temperature of neutrinos is discussed. From the available astronomical data the upper limit of muon neutrino rest mass has been obtained to be 130 eV. (auth)

**23185** FIELD-PARTICLE ASPECTS OF THE COSMOLOGICAL NEUTRINO PROBLEM. Kuchowicz, B. (Univ., Warsaw). pp 197-198 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jan 1972). See CONF-720651-(Vol.1).

The recent status on the role of the gravitational field in treating the neutrino is summarized. It is emphasized that the neutrino may be treated as a particle and as a field, and both a classical approach and a quantum one may be applied to it. (WDM)

## Planetary Phenomena

**23186** REVISION OF LUNAR Rb–Sr AGES. De Laeter, J. R.; Vernon, M. J.; Compston, W. (Australian National Univ., Canberra). Geochim. Cosmochim. Acta; 37: No. 3, 700-702(Mar 1973).

Recalibration of "spikes" using stoichiometric Rb and Sr salts recently issued by the National Bureau of Standards shows that Australian National University (ANU) determinations of the ratio $^{87}$Rb/$^{86}$Sr in lunar samples have been low by 1.8%, which is attributed to nonstoichiometry of the salts previously used for calibration, particularly RbCl. As a result, ANU lunar age-determinations must be decreased by this amount. (auth)

**23187** DIFFERENCE IN PHYSICAL STRUCTURE OF RELATIVISTIC ORDERS IN THE GRAVITATIONAL THEORIES OF EINSTEIN AND BIRKHOFF. Ivanitskaya, O. S. (Inst. of Physics, Minsk). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Mat. Navuk; No. 6, 65-72(1972). (In Russian).

A comparison was made of the structure of the relativistic error of displacement of the perihelion of a planet in the general theory of relativity (GTR) and the gravitational theory of Birkhoff. The method involved a division of the error into three parts–defects in the inherent magnitudes of the planet. A portion of the defect was caused by a "defect in natural time" (the difference between the natural time of the planet and the corresponding time of a distant observer). Other portions were identical. The source of the difference lay in the assumption in GTR on the components of the metric tensor as the gravitational potentials. The measurement of separate parts of the relativistic correction could reveal a nonalternating effect of the theories mentioned in this approximation, where they lead to the total value of the error identical with the GTR. (tr-auth)

**23188** ENERGETIC PARTICLES IN JUPITER'S MAGNETOSPHERE. Goertz, C. K. (Rhodes Univ., Grahamstown, S. Afr.). Astrophys. Lett.; 13: No. 2, 95-96(Feb 1973).

It is shown that electron streams of sufficient energy to explain the intense Jovian decametric radiation are subject to a Pierce–Buneman type instability. It is unlikely that the Io-controlled radiation can be generated by these streams. (auth)

**23189** SOME COMMENTS ON THE MAGNETOSPHERE AND PLASMA ENVIRONMENT OF SATURN. Scarf, F. L. (TRW Systems Group, Redondo Beach, CA). Cosmic Electrodyn.; 3: No. 4, 437-447(Jan 1973).

Some properties of a model magnetosphere for Saturn were studied in order to determine the bounds that can be set on the surface field strength and the trapped particle population. The primary observational constraint was that nonthermal radiation similar to the Jovian radio emissions must be undetectable from Earth. It is argued that for a Saturn surface field of approximately one gauss, those particles that are energized as they diffuse in from the magnetopause with conservation of magnetic moment will produce synchrotron radiation levels that are undetectable at a range of 9.5 AU. The plasma instabilities that heat the oncoming wind particles at the bow shock and others that can limit the stably-trapped flux levels are also discussed briefly. (auth)

# PHYSICS (ATMOSPHERIC)

## Auroral and Ionospheric Phenomena

*Refer also to abstracts 23146, 23208, and 23218.*

**23190** (AD-746314) TRAVELLING IONOSPHERIC DISTURBANCES. Final Report, October 1, 1967–September 30, 1971. Calderon, C. H. J.; Morgan, M. G. (Dartmouth Coll., Hanover, N. H. Thayer School of Engineering). 31 Oct 1971. Contract F19628-68-C-0099. 176p. (AFCRL-72-234). NTIS. Thesis.

A general study of traveling ionospheric disturbances was undertaken. In the theoretical aspect, the gravity-wave resonant mode was studied and the concept of an ionospheric predictive function was introduced. In the experimental aspect the digital data processing portion of the Dartmouth ionosonde network was brought into operation and seven TID events were analyzed with it. The data were interpreted in light of Hooke's theory and substantial agreement was found. (auth)

**23191** (N–72–29276) INVESTIGATION OF THE IONOSPHERIC D REGION AT SUNRISE. Turco, R. P.; Sechrist, C. F. Jr. (Illinios Univ., Urbana. Aeronomy Lab). 1 Dec 1970. 194p. (NASA-CR–127785; UILU-Eng–70-264). NTIS.

The growth over sunrise of the C and D layers of the ionosphere is investigated. The model that is analyzed includes the negative-ion species $O^-$, $O_2^-$, $O_3^-$, $O_4^-$, $NO_3^-$, $CO_3^-$, and $CO_4^-$. Ionization sources due to galactic cosmic rays, precipitated electrons, ionization of NO by scattered Lyman-alpha radiation, and the direct solar-radiation ionization are also included. The photodetachment of most of the negative ions is discussed, as well as the time variation of these parameters. The time variations of the electron, negative-ion, and positive-ion densities are calculated over sunrise. From these data, the mesospheric C- and D-layer development is plotted. Several model parameters are varied until the best agreement with experimentally determined electron densities is obtained. The results are discussed in light of several atmospheric parameters including the O and NO concentrations and the electron–ion recombination coefficient. (auth) (auth)

**23192** (N–72–29282) ANALYSIS OF AURORAL PARTICLE FLUXES. Final report. Chappell, C. R. (Lockheed Missiles and Space Co., Palo Alto, Calif. Research Labs). 1 Jun 1972. Contract NASw–2212. 63p. (NASA-CR-127783). NTIS.

The physical processes that describe the interaction of auroral electrons with the atmosphere appear to be more complex than just the Coulomb scattering of the incident primary electrons with a subsequent loss of energy. The comparison of the measured backscattered electron spectra with spectra predicted using a theoretical scattering calculation has led to a discrepancy for energies below about 1 to 2 keV. It was found that the very high ratio (100%) of backscattered-to-incident fluxes for these energies could be most reasonably explained by a parallel downward-directed electric field that prevents these lower energy electrons from entering the atmospheric scattering region. This parallel field with potential drop of about 1 keV is thought to have its origin in wave–particle interactions in the turbulent auroral ionosphere. (auth)

**23193** (N-72-31384) PHYSICS OF THE SPACE ENVIRONMENT. Smith, R. E.; Wu, S. T. (Eds.). (National Aeronautics and Space Administration, Washington, D. C.). 1972. 176p. (NASA-SP-305). NTIS.

Colloquium papers are presented on the physics of the upper atmosphere and on solar-flare forecasting. The topics include atmospheric heating, ionospheric currents, atmospheric structure, auroral red arcs, gravity waves, atmospheric composition, and atmospheric chemistry. (STAR)

**23194** (NP–19676) GEOGRAPHICAL MAPS OF THE AURORAL OVALS FOR DIFFERENT LEVELS OF GEOMAGNETIC DISTURBANCE. Technical Note 7. Bond, F. R.; Paine, R. L. (Department of Supply, Melbourne (Australia). Antarctic Div). Dec 1971. 54p. Dep. NTIS (U. S. Sales Only) $4.75.

Many geomagnetic coordinate systems are cited in the literature. All have been used for the location of magnetospheric and ionospheric phenomena against the datum line of the auroral zone or an auroral oval. The Akosofu (1968) auroral oval has been used as an approximate reference datum, but unfortunately, particularly in the northern hemisphere, the corresponding auroral zone is a circle rather than the near-ellipse shape derived from adiabatic theory and confirmed by experimental data. The method of deriving the location of the invariant auroral ovals, considered to be more accurate, is presented for each level of geomagnetic disturbance $K_p$. (4 tables, 37 figs., 24 references) (auth)

**23195** LOW-LATITUDE DENSITY VARIATIONS IN THE EARTH'S NEUTRAL ATMOSPHERE BETWEEN 200 AND 400 KM, FROM AUGUST 1969 TO MAY 1970. Knight, D. E.; Uribe, R.; Woodgate, B. E. (University Coll., London). Planet. Space Sci.; 21: No. 2, 253-271(Feb 1973).

The daily averages of the dawn and dusk observed exospheric temperatures (deduced from solar euv attenuation measurements between 250 and 400 km) are presented for 280 days from day 227, 1969. They are compared with the empirical model of the US Standard Atmosphere Supplements 1966 and the Jacchia 35 H model. Although consistently lower temperatures than either model were found, a better fit to the latter rather than the former was observed. The exospheric response to solar and geomagnetic activity is investigated, and refinements to the models are suggested. (auth)

**23196** MASS SPECTROSCOPIC INVESTIGATION OF DISSOCIATION AND IONIZATION IN A SIMULATED RE-ENTRY PLASMA. Trinks, H. (Deutsch Franzosisches Forschung-institut, St. Louis, France). Planet. Space Sci.; 21: No. 2, 291-296(Feb 1973).

With a new type of a miniaturized fourfold monopole mass spectrometer, the hypersonic flow around suitable model targets was investigated and gaseous reactions studied. Flow parameters are chosen such as to simulate the re-entry conditions of a spacecraft returning into the Earth's atmosphere. The dissociation of $N_2$ and $O_2$ is measured in the flow around a half sphere as well as in the stagnation point. Under the given condition the degree of ionization of $N_2$ never reached the sensitivity limit of 5%. $O_2$, however, was always dissociated to a measurable degree at the stagnation point, while in the flow noticeable dissociation occurred only with small gas density. Theoretical computations are in good agreement with the observed data. Three kinds of ions were found in the stagnation point, $NO^+$ abundance as predicted by theory is confirmed for high but not for low pressure. (auth)

**23197** ELECTRON DENSITY AND TEMPERATURE MEASUREMENTS IN THE LOWER IONOSPHERE AS DEDUCED FROM THE WARM PLASMA THEORY OF THE H. F. QUADRUPOLE PROBE. Chasseriaux, J. M. (Groupe de Recherches Ionospheriques, St. Maur, France); Debrie, R.; Renard, C. J. Plasma Phys.; 8: No. 2, 231-253(Oct 1972).

The frequency response of the hf quadrupole probe is calculated and used as a diagnostic tool for measurements of electron density and temperature. For a Maxwellian plasma, the so-called "Landau wave approximation" is compared with various more sophisticated treatments, such as numerical integration or super-Cauchy and multiple water-bag models. The range of validity of this approximation is shown to be large. It is deduced that the best way to determine the electron temperature is to use the anti-resonances due to beating between the Landau wave and the cold plasma field. The quadrupole probe, launched in December 1971 as part of the CISASPE rocket experiment, is described, and it is shown how the electron density and temperature profiles can be deduced from these measurements. (UK)

**23198** THEORETIC STUDY OF THE D REGION DURING SIDs. Kaufmann, P.; Matsuura, O. T.; de Barros, M. H. P. (Univ. Mackenzie, Sao Paulo, Brazil). Rev. Brasil. Fis.; 1: No. 1, 21-29(Apr 1971). (In French).

A new method is suggested to study the variations of the conductivity parameter in the D region during SIDs. The method makes use of propagation anomalies observed in vlf and seems to be particularly suitable for greater vlf wave lengths (12 kHz in the present work). An approximate typical model for the lower ionosphere is used. The conductivity gradients decrease during SIDs and the affected conductivities can be determined for fixed heights. (INIS)

**23199** APPROXIMATE METHOD FOR STUDYING POSSIBLE COLLISION FREQUENCY AND TEMPERATURE CHANGES IN THE D REGION DURING AN SID. Ananthakrishnan, S. (Univ. Mackenzie, Sao Paulo, Brazil). Rev. Brasil. Fis.; 1: No. 1, 31-36(Apr 1971).

Starting from the well-known Wait and Spies exponential conductivity model of the lower ionosphere, an expression is derived for the change in the collision frequency in the lower ionosphere during an SID. The resulting change in the collision frequency is then combined with the expression for the collision frequency of mono-energetic electrons, given by Phelps and Pack, to derive an expression for the change in neutral temperature. (tr-auth)

**23200** LABORATORY SIMULATION OF THE IONOSPHERIC PLASMA. Pigache, D. R. (National d'Etudes et de Recherches Aerospatiales, Chatillon, France). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 11: No. 2, 129-130(Feb 1973).

A correct simulation of the ionospheric plasma surrounding a satellite has been obtained in a large vacuum chamber by means of a synthesized plasma stream produced by a low-energy and high-current-density ion source. The plasma density and the beam velocity can be varied independently from $10^3$ to $10^6/cm^3$ for the density and from 7 to 30 km/sec for the velocity. The electron velocity distribution is Maxwellian, and the temperature can be varied between 500 and 2000°K. This plasma wind tunnel is being used for fundamental studies on the wake structure and for testing ionospheric probes. (auth)

**23201** THEORETICAL AND MEASURED ELECTRON-DENSITY DISTRIBUTIONS AT HIGH ALTITUDES. Kang, S. W. (Calspan Corp., Buffalo); Jones, W. L.; Dunn, M. G. AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 11: No. 2, 141-149(Feb 1973).

A viscous shock-layer analysis was developed and applied to the calculation of nonequilibrium-flow species distributions in the plasma layer of a blunt-nosed vehicle at high altitudes. The theoretical electron-density results obtained are in good agreement with those measured in flight for a hemisphere-9° cone entry vehicle. The flight measurements were obtained using electrostatic probes that protruded well into the shock layer. In addition, the theoretically obtained heavy-particle translational temperatures appear to agree fairly well with the electron temperatures that were measured in the flight experiments using voltage-swept thin-wire electrostatic probes. The influence of the reaction-rate coefficients on the calculated electron densities was assessed and shown to be within the uncertainty in the flight data. The theoretical results demonstrate the importance of including in the chemical model the positive ions $N_2^+$, $O_2^+$, $N^+$, and $O^+$, in addition to $NO^+$, for the high altitudes and velocities considered here. (41 references) (auth)

**23202** HIGH-FREQUENCY RADIO-WAVE PROPAGATION THROUGH PLANE-STRATIFIED IONOSPHERIC MODELS. Price, G. H. (Stanford Research Inst., Menlo Park, CA). Radio Sci.; 8: No. 2, 133-138(Feb 1973).

The sensitivity of refractive effects to profile shape in the propagation of high-frequency radio waves through the ionosphere is examined for a planar isotropic trapezoidal model of the electron-density variation with height. For a family of trapezoidal profiles with constant peak density, fixed orientation relative to a straight-line path from source to receiver, and constant integrated density along this path, the dependence of the group delay upon profile shape is found to involve only the ratio of the thickness of the peak-density segment of the profile to that of the total profile. For thin profiles, the theory suggests an insensitivity of the group delay to the profile shape for frequencies near the peak plasma frequency divided by the cosine of the zenith angle of the straight-line path, as well as in the familiar high-frequency limit. Expressions for the group delay are also given for parabolic and more generally linearly segmented profile models. (auth)

**23203** EASTERN THUNDERSTORMS LOCATED BY VLF ATMOSPHERICS PARAMETERS. Harth, W. (Max-Planck-Institut fuer Radioastronomie, Bonn); Pelz, J. Radio Sci., 8; No. 2, 117-122(Feb 1973).

Daily variations of spectral atmospherics parameters, as measured by the atmospheric analyzer of the Heinrich Hertz Institut in Berlin-Charlottenburg, are analyzed over an eight-day period for long-lasting storm centers within the octant NE-E (receiving station Stockert near Bonn). The delay-time difference and the amplitude ratio of spectral groups at 6 and 8 kHz were measured alternatively every 5 min. Within the first-mode approximation these parameters are proportional to the propagation distance. Storm centers located by these parameter measurements are compared with synoptical observations. As theory indicates, the strong directional dependence of the GDD (group delay-time difference) and the SAR (spectral amplitude ratio) on the propagation direction relative to the Earth's magnetic field is verified by these measurements. (auth)

**23204** IMPEDANCE OF AN ION-SHEATHED SPHERICAL PROBE IN A WARM, ISOTROPIC PLASMA. Aso, T. (Kyoto Univ.). Radio Sci.; 8: No. 2, 139-146(Feb 1973).

A self-consistent analysis of a radio-frequency impedance of a negatively biased spherical probe in a warm, isotropic plasma is given. Linearized zero- and first-order hydrodynamic and Maxwell equations are solved numerically for a specified probe-retarding potential, and the influence of a realistic sheath structure upon the resonance behavior is discussed. It is concluded that the usual abrupt-sheath model can safely be a good approximation for the study of radio-frequency properties of a probe immersed in a plasma. (20 references). (auth)

**23205** Vlf-lf HISS DURING POLAR SUBSTORM. Kokubun, Susumu; Makita, Kazuo; Hirasawa, T. (Tokyo Univ.). Rep. Ionosphere Space Res. Jap.; 26: No. 3, 138-148(Sep 1972).

There exist three categories of vlf hiss emissions in the auroral zone according to substorm condition and local time. Hiss emissions are often observed during the substorm growth phase. The growth phase hiss is accompanied by a fluctuation in the brightness of auroral arc or band. Impulsive hiss bursts occur just before the substorm onset. This hiss burst is characterized by a rapid intensity variation and a high-frequency peak. In the evening region, hiss is mostly observed during the expansion phase of substorm. The intensity variation of the evening hiss is not so rapid as compared with the hiss of the two former types. (22 references) (auth)

**23206** CHARACTERISTICS OF A SPHERICAL ELECTROSTATIC PROBE IN A WEAKLY IONIZED PLASMA. Tanaka, Takashi; Hirao, Kunio (Tokyo Univ.). Rep. Ionosphere Space Res. Jap.; 26: No. 3, 121-128(Sep 1972).

Characteristics of a spherical electrostatic plasma probe were studied in a weakly ionized $N_2$ plasma in the pressure range from 0.01 to 6 torr. At pressures near 0.01 torr, a probe still exhibits collisionless characteristics that are explained by the ordinary Langmuir theory; but as the pressure rises, this theory fails and transition to the continuum characteristics is observed. The nature of the electron saturation current exhibits three regions: a collisionless region where the saturation current is proportional to the surface area of the probe, a continuum region where the saturation current is proportional to the radius, and a transition region between them. The electron temperature was also measured in the three regions and compared with theoretical values. (auth)

**23207** CHERENKOV RADIATION BY ELECTRON BEAM INJECTED INTO THE IONOSPHERE. Alekhin, Yu. K.; Karpman, V. I. (Inst. of Terrestrial Magnetism, Ionosphere, and Radiowave Propagation, Moscow). Cosmic Electrodyn.; 3: No. 4, 406-415 (Jan 1973).

The spontaneous Cherenkov emission of longitudinal waves produced by a single particle and cylindrical electron beam moving inside the magnetosphere along the magnetic field is considered. The electric field of the radiation is calculated and compared with existing experimental results on artificial electron beams injected into space; the comparison shows a qualitative agreement between the theoretical results and experimental data. (auth)

## Effects of Nuclear Detonations

**23208** (UCRL-74425) COMMENTS ON THE POSSIBLE EFFECT OF $NO_X$ INJECTION IN THE STRATOSPHERE DUE TO ATMOSPHERIC NUCLEAR WEAPONS TESTS. Chang, J. S. (California Univ., Livermore. Lawrence Livermore Lab.). Jan 1973. 6p. (CONF-721137-1). Dep. NTIS.

From 2nd conference on the climatic impact assessment program; Cambridge, Massachusetts, USA (16 Nov 1972).

Some preliminary computations are made with a 1-D model combining diffusion and the $NO_x$ catalytic cycle. These indicated that the maximum reduction in $O_3$ would occur approximately 250 days after NO injection and would amount to <15% reduction in total $O_3$. If these effects of the NO injection are valid, one would not have expected them to be detectable by the examination of the $O_3$ observations reported by Foley and Ruderman previously (1972). It is concluded that the data reported by Foley and Ruderman are very inconclusive. (JCW)

## Magnetospheric Phenomena

*Refer also to abstracts 23081, 23193, and 23196.*

**23209** (N-72-31383) OBSERVATIONS OF PROTON SPECTRA ($1.0 \leq$ PROTON ENERGY $\leq$ 300 keV) AND PITCH-ANGLE DISTRIBUTIONS AT THE PLASMAPAUSE. Williams, D. J.; Fritz, T. A.; Konradi, A. (National Aeronautics and Space Administration, Houston, Tex. Manned Spacecraft Center). Jun 1972. 21p. (NASA-TM-X-68743; NOAA-TM-ERL-SEL-21). NTIS.

Detailed proton spectral and pitch-angle distribution observations were obtained from two proton detectors and a fluxgate magnetometer flown on Small Scientific Satellite A (Explorer 45). The data of interest are from orbit 99 in-bound occurring on December 17, 1971, some 8 hours prior to the sudden commencement of a magnetic storm. The data are consistent with the initiation of ion cyclotron instability when certain requirements are met. These criteria are met initially at the altitude at which the sudden intensity decrease occurs. However, after the initiation of the instability, the linear theory is unable to explain the further evolution of intensities, pitch-angle distributions, and energy spectra of the ring-current particles. (STAR)

**23210** (N-72-31394) MAGNETOSPHERIC ELECTRONS. Coroniti, F. V.; Thorne, R. M. (California Univ., Los Angeles. Plasma Physics Group). Jul 1972. 32p. (NASA-CR-122465; PPG-123). NTIS.

Coupling of source, transport, and sink processes produces a fairly accurate model for the macroscopic structure and dynamics of magnetospheric electrons. Auroral electrons are controlled by convective transport from a plasma sheet source coupled with a precipitation loss due to whistler and electrostatic plasma turbulence. Outer- and inner-zone electrons are governed by radial diffusion transport from convection and acceleration sources external to the plasmapause and by parasitic precipitation losses arising from cyclotron and Landau interactions with whistler and ion cyclotron turbulence. (auth)

**23211** (N-72-31397) UNIFIED THEORY OF STABLE AURORAL RED ARC FORMATION AT THE PLASMAPAUSE. Cornwall, J. M.; Coroniti, F. V.; Thorne, R. M. (California Univ., Los Angeles. Dept. of Physics). Nov 1970. Contract F04701-68-c-0200. 50p. (NASA-CR-122473; R-82). NTIS.

A theory is proposed that SAR arcs are generated at the plasmapause as a consequence of the turbulent dissipation of ring-current energy. During the recovery phase of a geomagnetic storm, the plasmapause expands outward into the symmetric ring current. When the cold plasma densities reach about 100/cm$^3$, ring-current protons become unstable and generate intense ion-cyclotron wave turbulence in a narrow region $\frac{1}{2}$ Earth radius wide (just inside the plasmapause). Approximately one-half of the ring-current energy is dissipated into wave turbulence that in turn is absorbed through a Landau resonant interaction with plasmaspheric electrons. The combined thermal heat flux to the ionosphere due to Landau absorption of the wave energy and proton–electron Coulomb dissipation is sufficient to drive SAR arcs at the observed intensities. It is predicted that the arcs should be localized to a narrow latitudinal range just within the stormtime plasmapause. They should occur at all local times and persist for the 10- to 20-hour duration of the plasmapause expansion. (auth)

**23212** (N-72-31398) RELATIVISTIC ELECTRON PRECIPITATION DURING MAGNETIC STORM MAIN PHASE. Thorne, R.M.; Kennel, C. F. (California Univ., Los Angeles. Plasma Physics Group). Nov 1970. 22p. (NASA-CR-122472; R-81). NTIS.

Relativistic electrons can have cyclotron resonances with electromagnetic cyclotron waves. The resonant energy is generally well above 1 MeV throughout the magnetosphere, but it can fall to 1 MeV just within the plasmapause. This also corresponds to the region where ring-current (10 to 50 keV) protons are expected to be strongly unstable. The resulting ion-cyclotron wave amplitudes necessary to precipitate ring-current protons lead to electron lifetimes near the strong diffusion limit (<100 sec). Thus >1 MeV electrons whose drift orbits intersect the stormtime plasmapause should rapidly be precipitated in the region $3 < L < 5$ during the initial phase of a magnetic storm. (auth)

**23213** (N-72-31695) DISPERSION DISCONTINUITIES OF STRONG COLLISIONLESS SHOCKS. Coroniti, F. V. (California Univ., Los Angeles. Dept. of Physics). Mar 1970. 53p. (NASA-CR-122474; R-67). NTIS.

Linear fluid equations are used to estimate wave train properties of strong collisionless shocks. Fast shocks exhibit several dispersion changes with increasing Mach number. For perpendicular propagation into a finite-beta plasma, an ion cyclotron radius trailing wave train exists only for $M_F2$ is smaller than 2. Oblique fast shocks have a leading ion inertia wave train if $M_A$ is smaller than root of $M(+)/M(-)$ cos $\theta/2$ and a trailing electron inertia train if $M_A$ is greater than root of $M(+)/M(-)$ cos $\theta/2$. If the downstream sound speed exceeds the flow speed, linear wave theory predicts a trailing ion acoustic structure which probably resides within the magnetic shock. For a turbulent shock model in which an effective electron–ion collision frequency exceeds the lower hybrid frequency, ions decouple from the magnetic field; the shock wave train now trails with electron inertia and electron gyroradius lengths. Comparisons of this turbulent model and observations on the Earth's bow shock are made. (auth)

**23214** (UCRL–51314) LLL ELECTRON AND PROTON SPECTROMETER ON NASA's ORBITING GEOPHYSICAL OBSERVATORY V(E): THE THREE-WAY MERGED TAPE (AN ARCHIVAL DATA BASE). Zeligman, M. M.; Walton, J. R. (California Univ., Livermore. Lawrence Livermore Lab.). 7 Dec 1972. Contract W-7405-Eng-48. 186p. Dep. NTIS.

This is a description of a data base that can be used for archival records. The data are combined from three sources and thus the name of the resultant tape: The Three-Way Merged Tape. The data contained on these tapes came from the following sources: the LLL Electron and Proton Spectrometer (Experiment E-06) on NASA's Orbiting Geophysical Observatory V(E), attitude-orbit tapes containing the satellite ephemeris provided by Goddard Space Flight Center, and magnetometer tapes provided with data from the Triaxial Fluxgate Magnetometer Experiment (Experiment E-14) on OGO-5. (auth)

**23215** PLASMA SHEET PARTICLE PRECIPITATION. A KINETIC MODEL. Lemaire, J.; Scherer, M. (Institut d'Aeronomie Spatiale de Belgique, Brussels). Planet. Space Sci.; 21: No. 2, 281-289(Feb 1973).

Ionospheric and plasma-sheet particle densities, fluxes, and bulk velocities along an auroral magnetic-field line have been calculated for an ion-exosphere model. It is shown that such a collisionless model accounts for many features observed above the auroral regions. Except for very strong plasma-sheet electron precipitation, no large potential difference is needed along the magnetic-field lines to account for the usual proton and electron fluxes, their pitch-angle distributions, and auroral field-aligned currents. (auth)

**23216** ELECTRON INTENSITIES OVER TWO AURORAL ARCS. Bryant, D. A.; Courtier, G. M.; Bennett, G. (Radio and Space Research Station, Ditton Park, Eng.). Planet. Space Sci.; 21: No. 2, 165-177(Feb 1973).

Electron intensities observed on two rocket flights over auroral arcs are discussed. On both occasions there was an order-of-magnitude increase in the electron phase-space density as the rocket moved northwards across the arc from a southern region of relatively hard precipitation to an adjacent northern region of softer (but still intense) precipitation. These two distinct regions formed northern and southern "curtains" to the arcs. Electrons observed to the south of one of the arcs had the same phase-space density as those in the southern curtain of the arc. It is concluded that the electrons producing the auroral arcs were accelerated at the boundary between two source plasmas in the magnetosphere. The possible identity of the source plasmas is discussed. From the various types of electron energy spectra encountered it is suggested that time-varying magnetic fields played an important part in the acceleration of the electrons that produced the auroral arcs. (auth)

**23217** COMPUTATION OF ANGULAR PARTICLE DISTRIBUTION IN THE MAGNETOSPHERE. Kasymov, U.; Shabanskii, V. P. (Moscow State Univ.). Geomagn. Aeron. (USSR) (Engl. Transl.); 12: No. 3, 507-509(1972).

Translated from Geomagn. Aeron.; 12: No. 3, 571-572(1972).

Magnetic particle drift in the geomagnetic field takes place with conservation of the first two adiabatic invariants of motion. A discussion is given of previous computations of magnetic drift shells, and results are given of the calculations for the noon and midnight meridians based on the two-dipole model with the same parameters used by Antonova and Shabanskii, 1968. (JCW)

**23218** OSCILLATION OF DP1 AND DP2 CURRENT SYSTEMS. Tashkinova, L. G.; Tverskoi, B. A. (Moscow State Univ.). Geomagn. Aeron. (USSR) (Engl. Transl.); 12: No. 3, 509-512(1972).

Translated from Geomagn. Aeron.; 12: No. 3, 573-574(1972).

A longitudinally asymmetric plasma cloud of protons with energies 10 to 50 keV is observed during the main phase of a substorm in the magnetosphere. The appearance of this cloud and its symmetrization are accompanied by polarization drift, charge compensation by currents along the lines of force, and the closing of these currents through the ionosphere. The arising electric field is carried into the ionosphere, concentrates along the boundaries of polar caps, and excites a corresponding current system. Barium cloud experiments showed that these systems have Hall currents. The consequences of the appearance of an asymmetric plasma cloud in a trap with conducting ends, such as the geomagnetic field, show the conductivity of the ionosphere was assumed to be constant. It proved that the fast-particle density gradient along magnetic drift trajectories in the trap induces currents and electric fields that attenuate exponentially. Allowance is made for the inhomogeneity of ionospheric conductivity, i.e., the low conductivity of the polar cap, in the framework of the same model, but with other boundary conditions: a transverse potential and a normal current component. Calculations show a reduction in conductivity in the polar cap produces the oscillatory character of attenuation of the zeroth short-lived harmonic, corresponding to the DP2 current system. The first harmonic, corresponding to the DP1 system, oscillates with a period that is much greater than its characteristic attenuation time, i.e., it actually attenuates aperiodically. (JCW)

**23219** BALLOON OBSERVATIONS OF AURORAL-ZONE X RAYS IN CONJUGATE REGIONS. Barcus, J. R. (Univ. of Denver); Brown, R. R.; Karas, R. H.; (and others). J. Atmos. Terrest. Phys.; 35: No. 3, 497-511(Mar 1973).

Conjugate aspects of auroral-zone electron precipitation are examined using x-ray data obtained from balloon flights launched from conjugate sites, Reykjavik, Iceland and Syowa, Antarctica, in the winter of 1969. In spite of the close conjugacy of these sites, dissimilarities were noted between observations in the two hemispheres, especially for midnight events. This is attributed in part to balloon drift and motions of narrow precipitation regions. For a dayside event, close conjugate relations were found even though the x-ray detectors were out of conjugacy by approximately 700 km. Riometer data from this event suggest that the intensity of electron precipitation was significantly smaller in the southern hemisphere. (auth)

**23220** EVENING/FORENOON ASYMMETRY IN THE 27-DAY OSCILLATION OF THE LOW-LATITUDE MAGNETIC FIELD. Bhargava, B. N. (Indian Inst. of Geomagnetism, Colaba). J. Atmos. Terrest. Phys.; 35: No. 3, 567-570(Mar 1973).

Power spectra of low-latitude horizontal intensity, computed from a series derived from observations restricted to different local times, reveal a large evening/forenoon asymmetry in the magnitude of the 27-day oscillation of the field. The asymmetry is observed during periods of declining phase of the solar cycle and is very pronounced during periods of high activity. It is considered that selective data derived from afternoon/evening observations of the field in the low latitudes by virtue of their high signal-to-noise ratio are likely to be most useful in the investigations of the 27-day variation and in the study of fine structure of the 27-day line in the spectra of the field. (auth)

**23221** PENETRATION OF HYDROMAGNETIC WAVES FROM TAIL OF THE MAGNETOSPHERE INTO THE POLAR CAP. Bol'shakova, O. V.; Gul'el'mi, A. V. (Inst. of Terrestrial Physics, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.); 12: No. 3, 505-507(1972).

Translated from Geomagn. Aeron.; 12: No. 3, 569-570(1972).

An experimental study was made of the penetration of Pc2 geomagnetic pulsations from the magnetotail into the polar cap, Pc2 pulsations being T ~ 5 to 15 sec. These pulsations may penetrate into the polar cap from the tail, and they may also be excited in the polar ionosphere. An investigation was made of the OGO-5 data of Aug. 9, 1968 to verify this phenomenon. The origin of the leading PD and lagging Pc2 effects is explained. As the solar-wind inhomogeneity advances on the magnetosphere, irregular PD appear in the polar cap at the instant of first contact. As the inhomogeneity moves along the tail it disturbs the particle distribution in the tail so that self-excitation of magnetic pulsations occurs. The pulsations propagate along the tail and along the tube to penetrate into the polar cap in the Pc2 form. (JCW)

**23222** PINCH EFFECT AND THE STRUCTURE OF THE MAGNETOSPHERE. Raspopov, O. M.; Koshelevskii, V. K. Uch. Zap. Leningrad. Gos. Univ., No. 366, Ser. Fiz. Geol. Nauk; No. 22, 223-232(1972). (In Russian).

The nonhomogeneous structure of the magnetosphere is filamentous in character, its elements being parallel with the magnetic field. Investigations of the auroral plasma in the ionosphere demonstrated the existence of a pinch effect. The results of calculations of particle fluxes (protons and electrons) in the magnetosphere are compared with those experimentally observed, and the width of the zone of precipitation of such particles was studied as a function of the magnitudes and energies of the fluxes. (KSW)

**23223** GEOMAGNETIC FIELD MODELS: SCALAR AND VECTOR POTENTIAL, INDUCTION VECTOR AND ITS GRADIENT TENSOR COMPUTED BY A COMMON ALGORITHM. Kluge, G. (ESOC, Darmstadt, Ger.). Comput. Phys. Commun.; 4: No. 3, 347-360(Dec 1972).

The program has been written for handling phenomenological models of the geomagnetic field; it can be adapted to any spherical harmonic expansion of potentials (e.g. gravitational or electrostatic). The scalar potential is expressed as a harmonic polynomial in terms of Cartesian coordinates with reciprocal radius. Derivatives of any order can be simply calculated in a way similar to Horner's procedure. This results in a unified algorithm for the various field quantities and also facilitates the generation and use of local approximations to field models. (WDM)

**23224** PLASMA WAVES WITH LOW GROUP VELOCITY. Petit, M. (Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux, France); Bitoun, J.; Feldstein, R.; Higel, B.; Graff, P. Ann. Telecommun.; 27: No. 9, 417-429(Sep 1972). (In French).

Low group velocity waves appear to be a promising way of studying very tenuous plasmas found in the distant magnetosphere. The techniques used to study plasmas are presented: resonance peaks, fine structure of the resonances at the plasma frequency and the upper hybrid frequency, and resonances at the harmonics of the electron gyrofrequency. (France)

**23225** RELATIONSHIP OF MAGNETOSPHERIC SUBSTORMS ON THE GROUND AND IN THE DISTANT MAGNETOTAIL. Iijima, Takesi (Tokyo Univ.). Rep. Ionosphere Space Res. Jap.; 26: No. 3, 149-157(Sep 1972).

From comparison of the simultaneous magnetic-disturbance fields on the ground and in the distant magnetotail (20 to 40 $R_E$) for 64 isolated substorms, the following characteristics are statistically confirmed: (1) the majority of magnetospheric substorms show a growth phase ~1 hour preceding the grand expansion of the auroral-electrojet field; (2) the growth phase is the stage wherein the magnetosphere configuration becomes strained and the storage of strain energy proceeds by virtue of excess of energy supply over energy release in the magnetosphere; (3) the expansion phase is the stage wherein the strained magnetosphere collapses substantially so as to reveal a more stable configuration; and (4) the two basic competing processes of energy supply and energy release proceed differentially in the magnetosphere during the course of a substorm, which appears as the qualitative difference between the growth phase and the expansion phase. (20 references) (auth)

**23226** SELF-CONSISTENT MODEL OF A SIMPLE MAGNETIC NEUTRAL SHEET SYSTEM SURROUNDED BY A COLD, COLLISIONLESS PLASMA. Cowley, S. W. H. (Imperial Coll. of Science and Tech., London). Cosmic Electrodyn.; 3: No. 4, 448-501(Jan 1973).

Previous theories of magnetic field annihilation at neutral sheets (or reconnection at X-type neutral lines) in the presence of a conducting plasma are appropriate only to collision-dominated fluids with scalar conductivities. Considerations of self-consistent flow-field models for the collisionless case are different, requiring knowledge of particle trajectories in order to obtain the charge and current distributions, and have been little studied. It is assumed that the only current source for the neutral sheet is the plasma contained on the field lines of the system; this implies a fixed voltage drop across it, and hence a fixed reconnection rate. The basic properties are investigated via the self consistency requirements of the current and magnetic field, conservation of energy and momentum, and charge neutrality. The results imply that the voltage drop is localized in the current sheet over a length along the sheet of dimension $\bar{\lambda}_p$, the proton plasma wavelength, near the boundary where protons leave the system. This also implies that ion flow energies above the sheet approach the potential energy across the system, and the theory of drifting plasma has been generalized to include this case. The current over most of the sheet is carried by a thin electron beam whose characteristic thickness is $(m_e/m_p)\bar{\lambda}_p$. (auth)

**23227** CHARGED PARTICLE FLUXES AT ALTITUDES OF 200 TO 300 km BY MEANS OF THE ORBITING STATION "SALYUT". Konyakhina, S. S.; Kurnosova, L. V.; Logachev, V. I.; Razorenov, L. A.; Sinitsina, V. G.; Fradkin, M. I. Izv. Akad, Nauk SSSR, Ser. Fiz.; 36: No. 11, 2441-2446(Nov 1972). (In Russian).

A Cherenkov scintillation telescope aboard the orbiting spaceship "Salyut" was employed in recording the background intensity of charged particles at 200 to 300 km above the Earth (June 1971). The data are compared with those from seven other artificial satellites. (KSW)

**23228** RESULTS FROM A GROUP OF RADIOSOUNDINGS FROM THE KOLA PENINSULA DURING THE MAGNETIC DISTURBANCES MARCH TO APRIL 1971. Kvashnin, A. N.; Kuz'min, I. A.; Kukushkin, A. A.; Lazutin, L. L.; Mel'nikov, A. O.; Stozhkov, Yu. I.; Svirzhevskii, N. A.; Shchur, L. I. (Polar Inst. of Geophysics, Apatity, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2435-2440(Nov 1972). (In Russian).

The effect of a release of high-energy electrons (E > 20 keV) in the auroral zone was studied from March 13 to April 11, 1971, from a station on the Kol'sk Peninsula from which a series of radiosonde flights had been released. Intrusions of electrons were recorded through measurements of bremsstrahlung fluxes in the stratosphere, and simultaneously surface observations were conducted at six other stations of the magnetic field and of the polar aurora. (KSW)

# PHYSICS (ATOMIC AND MOLECULAR)

## Beams and Their Reactions

*Refer also to abstracts 22847, 23770, 23782, and 23783.*

**23229** STUDY OF THE SEMICONDUCTOR CRYSTAL SURFACE: STRUCTURE REARRANGEMENT USING HEAVY-ION-SCATTERING TECHNIQUE. Molchanov, V. A.; Snisar, V. A. (Moscow State Univ.). Surface Sci.; 33: No. 2, 221-227(Nov 1972).

The angular and spatial distributions of energetic particles ejected from silicon targets during bombardment by neon, argon, or krypton ions were studied experimentally over a wide (250 to 800°C) temperature range. The incident ion energy was varied from 10 to 30 keV. Information about the structural rearrangement of the target surface may be obtained by analysing these distributions. (auth)

**23230** IMPROVEMENTS IN OR RELATING TO APPARATUS FOR GENERATING ION BEAMS. Pease, R. S.; Peacock, N. J. (to United Kingdom Atomic Energy Authority). British Patent 1,299,381. 13 Dec 1972. Filed date 29 May 1969. 5p.

Apparatus is described for generating ion beams in which a laser source is used for producing a plasma within a magnetic confinement system. The latter has at least one loss region from which the plasma escapes, and means are provided for accelerating ions from the escaping plasma. Means are provided for focussing the laser beam within the plasma confinement system, and also for injecting into the latter a solid particle containing the element to be ionized with a trajectory that passes through the focal point of the laser beam. Arrival of a particle at the focal point triggers the laser source. (UK)

**23231** IMAGINARY TIME METHOD IN ATOM IONIZATION AND PAIR PRODUCTION PROBLEMS. Popov, V. S. (Inst. of Theoretical and Experimental Physics, Moscow). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1586-1598(Nov 1972). (In Russian).

The "imaginary time" method is formulated in a form most general and convenient for application. The relation between atom ionization processes induced by a strong light wave and pair production from vacuum by an electric field F(t) is elucidated. A closed expression for the ionization probability w valid for an arbitrary dependence of F(t) on time, is found for the case of linear polarization. The calculation of the Coulomb correction to probability w is discussed. (auth)

**23232** UNIFIED DESCRIPTION OF THE PROFILE OF RESONANCE LINES IN THE ENERGY SPECTRA OF SCATTERED AND EJECTED ELECTRONS. Balashov, V. V.; Lipovetskii, S. S.; Senashenko, V. S. (Moscow State Univ.). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1622-1627(Nov 1972). (In Russian).

A unified description of the resonance line profiles in the energy spectra of scattered and ejected electrons is proposed on basis of the diagonalization method of calculation of atomic autotionized states. Calculations are carried out for the (2s2p) $^1P^{(-)}$ resonance of the helium atom. Interference between the resonance and direct transitions to a continuous spectrum leads to a strong dependence of the resonance line profile on ejection angle. The calculations can explain the regularities observed in an experiment with fast electron beams. (auth)

**23233** ACCELERATION OF ATOMS BY A RESONANCE FIELD. Kazantsev, A. P. (Inst. of Applied Physics, Moscow). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1628-1634(Nov 1972). (In Russian).

It is shown that intense laser radiation can be employed for accelerating atoms. In a field of a special shape (22) the effective atomic potential is a sinusoid moving with uniform acceleration. The acceleration of the captured atoms is proportional to the variation of the field frequency. It is shown that under practically attainable conditions the velocity of the atom in the excited state may reach $10^8$ cm/sec. (auth)

**23234** PROPOSED EXPERIMENTS COMPLEMENTARY TO THOSE OF SCHWARZ AND HORA. Elliott, J. A. (Univ. of Manchester, Eng.). J. Phys., C (London); 6: No. 1, L26-L28(17 Jan 1973).

The experiments of Schwarz and Hora on the modulation of an electron beam at optical frequencies by passing the beam through a thin dielectric crystal illuminated by intense laser light (Schwarz and Hora, App. Phys. Lett.; 15: 349-51(1969)), Schwarz, Trans. N. Y. Acad. Sci.; 33: 150-162(1971)) have aroused much interest, and have stimulated much theoretical and experimental work on the subject. However, it appears that no workers have yet been successful in repeating the original experiments independently. Experiments are now proposed which investigate the processes involved without demanding the high electron-beam coherence which has proved the main source of difficulty. (auth)

## Atomic and Molecular Properties

*Refer also to abstract 22217.*

**23235** (KFKI-72-69) RESONANCE MULTIPHOTON IONIZATION. Bakos, J.; Kiss, A.; Szabo, L.; Tendler, M. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). Dec 1972. 19p. (CONF-720976-2). Dep. NTIS (U. S. Sales Only).

From Conference on interaction of electrons with strong electromagnetic field; Balatonfuered, Hungary (11 Sep 1972).

The five-photon ionization of metastable helium atoms was investigated in the case of a four-photon resonance with atomic levels lying in the energy range close to the ionization limit, where the states are closely packed. The dependence of the five-photon ionization yield on the light intensity and frequency was measured. Using the experimental results, the distortion of the atomic structure in light fields of high intensity, i.e., the dependence of atomic term energy on the light intensity, was determined. Some limitations to the applicability of perturbation theory were revealed. (auth)

**23236** CFPJJ: FRACTIONAL PARENTAGE COEFFICIENTS FOR EQUIVALENT ELECTRONS IN JJ-COUPLING. Grant, I. P. (Oxford Univ.). Comput. Phys. Commun.; 4: No. 3, 377-381 (Dec 1972).

Antisymmetric wavefunctions of N identical particles can be expressed as linear combinations of antisymmetric wavefunctions for (N − 1) such particles multiplied by single-particle wavefunctions with the aid of coefficients of fractional parentage. When the particles are electrons described by Dirac's equation, it is natural to use jj-coupling. (WDM)

**23237** $H_2^+$ DIPOLE STRENGTHS BY ASYMPTOTIC TECHNIQUES. Ramaker, D. E.; Peek, J. M. (Sandia Labs., Albuquerque, NM). J. Phys., B (London); 5: No. 12, 2175-2181 (Dec 1972).

Asymptotic expansions in the internuclear separation $R^{-n}$ of the dipole transition moments $Q(R) = \langle\psi\,(r|R)|r|\psi(r|R)\rangle$ involving the electronic Born–Oppenheimer states of $H_2^+$ are presented. The four leading terms of all nonzero dipole transition moments involving the 20 states correlating to a proton and a hydrogen atom with principal quantum number n = 1, 2, and 3 are given. Numerical calculations indicate the expansions are useful beyond $R = 10a_0$ for transitions involving only the n = 1 states. The useful range decreases with increasing n, as expected. The coefficients of the charge transfer transitions can be related to the permanent dipole and polarizability of the hydrogen atom in the field of a proton. A perturbative approach due to Coulson (Proc. R. Soc. A.; 61: 20-6 (1941)), usable for larger systems, was found to give the same asymptotic coefficients. (auth)

**23238** PERTURBATION CORRECTIONS TO HARTREE–FOCK OSCILLATOR STRENGTHS FOR HELIUM. Devine, K. R.; Steqart, A. L. (Queen's Univ., Belfast). J. Phys., B (London); 5: No. 12, 2182-2186(Dec 1972).

A calculation of optical dipole transition oscillator strengths between the $1\ ^1S$, $2^{1,3}S$, $2\ ^{1,3}P$, $3^{1,3}S$, $3^{1,3}P$ and $3^{1,3}D$ states of helium using perturbation theory is described. The method is based on zero order wave functions generated by the frozen core Hartree–Fock approximation. The results to second order are in excellent agreement with the values calculated by Pekeris and co-workers (1959, 1964, 1967, 1971). (auth)

**23239** COHERENT STATES FOR $\gamma$-LEVEL ATOMS. Arecchi, F. T. (Univ., Pavia, Italy); Gilmore, R.; Kim, D. M. Lett. Nuovo Cim.; 6: No. 6, 219-223(10 Feb 1973).

The SU(2) formalism for 2-level atoms is extended to an SU($\gamma$) formalism for $\gamma$-level atoms. The analogs for $\gamma$-level atoms of the Dicke and Block states for 2-level atoms are constructed. The important mathematical properties for ensembles of systems with $\gamma$-internal degrees of freedom are described. (L.B.S.)

**23240** RELATIVISTIC CONTRIBUTIONS TO SCREENING RATIOS IN EUROPIUM. Coulthard, M. A. (Monash Univ., Clayton, Australia). J. Phys., B (London); 6: No. 1, 23-29(Jan 1973).

Relativistic Hartree–Fock calculations of the electron density at the nucleus in Eu yield improved agreement with empirical screening ratios. It is shown that this is due to the relativistic enhancement of the change in density being strongly dependent upon whether s or p electrons or d or f electrons are excited. (auth)

**23241** ISOTOPE SHIFT AND HYPERFINE STRUCTURE IN THE ATOMIC SPECTRUM OF TIN. Silver, J. D.; Stacey, D. N. (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A, 332: No. 1588, 129-138(6 Feb 1973).

Three lines in the atomic spectrum of tin, λ3262 Å, λ3283 Å and λ6454 Å, have been studied in emission under high resolution with the use of light sources containing enriched isotopic samples. Results are reported for isotope shifts in these lines for the abundant stable isotopes ($A \geq 116$). Pressure-scanned Fabry-Perot etalons provided the necessary resolution; the spectrograms for λ6454 Å were recorded and analyzed by digital techniques, and for this line hyperfine structure constants required in the interpretation of the data were also evaluated. The results for the three lines are not in good agreement with earlier work, but are shown to be self-consistent by means of a King plot. (auth)

**23242** PRECISE DETERMINATION OF ATOMIC MASSES. Williams, P.; Duckworth, H. E. (Manitoba Univ., Winnipeg). Sci. Progr. (Oxford); 60: No. 239, 319-336(Aug 1972).

The relative masses of atoms give information about the binding energies of their component particles. By precise comparison of the masses of two atoms which differ by one or two nucleons, the binding energy of this nucleon or nucleon pair may be determined. Mass spectrometer design and measurement techniques are described, and the present status of atomic mass determination is reviewed. The results of a study of double-neutron separation energies show how information about nuclear structure may be obtained by precise atomic mass determination. (auth)

**23243** EXPERIMENTAL AND THEORETICAL STUDIES ON NON-ADIABATIC ION DYNAMIC CONTRIBUTIONS TO THE He I 4026 $2^3P-5^3D$, $5^3F$ PROFILE AT LOW ELECTRON DENSITIES. Mahon, R.; Lee, R. W.; Burgess, D. D. (Imperial Coll. of Science and Tech., London). J. Phys., B (London); 6: No. 2, 354-363(Feb 1973).

The He I 4026 $2^3P-5^3D$, $5^3F$ transition has been observed in a recombination plasma at low electron densities. The profile is in very poor agreement with all existing static ion theories and the discrepancies are different in form from those for the 2P-4D transitions studied previously. New theoretical predictions are also presented showing greatly improved agreement with the experiment, and emphasizing the importance of nonadiabatic ion dynamic broadening of the forbidden component. These results cast doubt on all existing criteria for the static approximation even when frequency separations are correctly measured from the center of the forbidden component. (auth)

## Positronium, Muonium, and Muonic and Mesic Atoms and Molecules

*Refer also to abstract 22262.*

**23244** (JINR-P4-6919) CALCULATION OF THE ENERGY LEVELS FOR HYDROGEN MESIC MOLECULES TAKING INTO ACCOUNT THE ADIABATIC CORRECTIONS FOR NUCLEUS MOTION. Ponomarev, L. I.; Puzynin, I. V.; Puzynina, T. P. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1973. 18p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

Binding energies were calculated for all known vibrational levels in hydrogen mesic molecules $pp\mu$, $dd\mu$, $tt\mu$, $pd\mu$, $pt\mu$ and $dt\mu$. In the mesic molecules $dd\mu$ in the state with the orbital momentum $L = 1$ a new vibrational level $v = 1$ of small binding energy $\epsilon = 0.7$ eV was found. In calculating, the first order adiabatic corrections for nucleus motion were taken into account. (auth)

**23245** MEASUREMENT OF THE AUGER EFFECT IN THE $(\mu^4He)^+_{2s}$ IONIC SYSTEM. Carboni, G. (CERN, Geneva); Placci, A.; Zavattini, E.; Gastaldi, U.; Gorini, G.; Pitzurra, O.; Neri, G.; Polacco, E.; Torelli, G.; Duclos, J.; Picard, J.; Vitale, A. Lett. Nuovo Cim.; 6: No. 7, 233-237(17 Feb 1973).

The contribution of the external Auger effect on the de-excitation of the $(\mu^4He)^+_{2s}$ system was measured. The de-excitation rate was determined as a function of helium pressure in order to optimize the apparatus. It is concluded that one can use a high-pressure helium target (up to 50 atm. or more) to produce metastable states $(\mu^4He)^+_{2s}$. (LBS)

**23246** COMPOSITENESS CONDITIONS AND DESCRIPTION OF POSITRONIUM IN QUANTUM ELECTRODYNAMICS. Braun, M. A.; Izergin, A. G. Vestn. Leningrad. Univ., No. 16, Fiz., Khim.; No. 3, 7-18(Aug 1972). (In Russian).

The compositeness conditions formalism suggested earlier has been applied to describe the particles with identical quantum numbers (orthopositronium and photon) in quantum electrodynamics. Ultraviolet divergences in the compositeness conditions are shown to cancel. Binding energy and decay constant of orthopositronium are calculated. (auth)

**23247** POSITRON ANNIHILATION LINESHAPE STUDIES AS A SUPPLEMENTARY METHOD TO LIFETIME MEASUREMENT. Ito, Y.; Okada, S.; Arai, Y.; Tabata, Y. (Tokyo Univ.). Chem. Phys. Lett.; 18: No. 2, 300-302(15 Jan 1973).

We studied positron annihilation lineshapes by a Ge(Li) γ-ray spectrometer for $CCl_4$ solution in benzene and two monomer crystals which are polymerized by γ-ray irradiation. From the lineshapes we evaluated the para-positronium intensity, and the results agree well with those of lifetime measurements in the cases of $CCl_4$ solutions in benzene and solid acrylamide. But in solid dimethylitaconate the results from the two different methods have not agreed. (auth)

## Collision Phenomena

*Refer also to abstract 23447.*

**23248** (BNWL-SA-4167) EFFECT OF MOLECULAR BINDING ON PRIMARY IONIZATION. Wilson, W. E.; Toburen, L. H.; Glass, W. A. (Battelle Pacific Northwest Labs., Richland, Wash.). Dec 1971. Contract AT(45-1)-1830. 12p. (CONF-720430-11). Dep. NTIS $3.00.

From second symposium on sharing of computer programs and technology in nuclear medicine; Oak Ridge, Tennessee, USA (21 Apr 1972).

Cross sections, differential in ejection energy and angle, for electron emission from methane, ethane, ethylene, acetylene and benzene molecules following proton impact have been measured for protons of 0.3 and 1.0 MeV. The purpose in making the measurements is to look for an effect on the electron yield attributable to the chemical form or molecular binding of the target atoms. The results for the five molecules indicate that for many practical situations involving energy transport by energetic secondaries there is no significant binding effect. However, when the results are compared with similar data for molecular hydrogen, one observes an apparent difference in the amount of ionization per carbon atom depending on the degree of saturation of the hydrocarbon. The more highly saturated molecules, (methane, ethane, ethylene) appear to produce, per carbon atom, more secondary electrons with energies up to 60 eV, than do the less saturated benzene and acetylene. The observation suggests that the amount of ionization produced in a hydrocarbon gas may be quite different from what one would calculate by summing the contributions of the atomic constituents of the gas. (auth)

**23249** (RLO-1388-189) EFFECT OF MULTIPLE IONIZATION ON THE FLUORESCENCE YIELD OF Ne. Burch, D.; Ingalls, W. B.; Risley, J. S.; Heffner, R. 1972. 11p. Dep. NTIS $3.00.

K Auger electron and K x-ray yields of Ne have been measured simultaneously in 30-MeV $O^{7+}$ collisions with Ne. Both spectra are dominated by satellite transitions. The Ne K-shell fluorescence yield is 2.4 times larger than found in identical measurements using 5-MeV incident protons. (auth)

**23250** COMPUTER PROGRAMS FOR THE CALCULATION OF ELECTRON-ATOM COLLISION CROSS SECTIONS. 1. General Formulation. Eissner, W.; Seaton, M. J. (University Coll., London). J. Phys., B (London); 5: No. 12, 2187-2198(Dec 1972).

The wavefunction for electron collisions with an N-electron atom is expanded in the form $\Psi = \Sigma_i \Theta_i + \Sigma_j \Phi_j c_j$ where $\Theta_i$ is an anti-symmetrized product of an atomic eigenfunction times an orbital function $\Theta_i$ for the colliding electron; $\Theta_i$ contains a radial function $F_i$; $\Phi_j$ has the form of a bound state function for the (N + 1)-electron problem. The condition is imposed that $(P_\gamma | F_i) = 0$ if $l_\gamma = l_i$, where $P_\gamma$ is an atomic radial function and where $l_\gamma$ and $l_i$ are orbital angular momenta associated with $P_\gamma$ and $F_i$; this condition does not imply a restriction on $\Psi$ so long as a suitable set of states $\Phi_j$ is included. The variational principle is discussed and two approximations are described: The distorted wave (DW) approximation is valid when the coupling is not too strong. Particular attention is paid to the normalization of the DW functions $F_i$. The coefficients $c_j$ are determined using the variational principle. The variational principle is used to obtain a set of coupled integro-differential (ID) equations for the determination of the functions $F_i$ and the coefficients $c_j$. (auth)

**23251** INTERFERENCE EFFECT IN THE ENERGY DISTRIBUTION OF ELECTRONS DUE TO TWO-FOLD PASSAGE OF THE QUASI STATIONARY TERM. Ostrovskii, V. N. Vestn. Leningrad. Univ., No. 16, Fiz., Khim.; No. 3, 31-36(Aug 1972). (In Russian).

A model problem has been solved to investigate the energy distribution of electrons detached in slow atomic collisions. Further generalization of the results to be applied to more complicated cases is proposed. The detachment of electron with the same energy may occur in different parts of the nuclei trajectory. The resulting interference leads to oscillatory structure in the energy distribution. (auth)

**23252** INNER SHELL IONIZATION OF ATOMS BY ELECTRON IMPACT. Burhop, E. H. S. (University Coll., London). J. Phys., B (London); 5: No. 12, L241(Dec 1972).

An error is pointed out in the expression given many years ago (Burhop. Proc. Camb. Phil. Soc.; 36: 43 (1940)) for the differential cross section for ionization by electron impact of the 2p ($m = \pm 1$) states of a hydrogenic atom, calculated using Born's approximation. (auth)

**23253** ENERGY DEPENDENCE OF THE DIFFERENTIAL COLLISION CROSS SECTION FOR HYDROGEN AT THERMAL ENERGIES. Dondi, M. F. (Univ., Genoa); Valbusa, U.; Scoles, G. Chem. Phys. Lett.; 17: No. 1, 137-149(1 Nov 1972).

In a crossed beam molecular scattering apparatus the energy dependence of the differential collision cross section for hydrogen has been measured. Comparisons with cross sections computed from different potentials are presented and discussed. Preliminary conclusions on the shape of the intermolecular potential energy function are reported. (auth)

**23254** INELASTIC ELECTRON IMPACT CROSS-SECTIONS OF $H_2$ AND $N_2$. Sharma, V. N.; Tripathi, D. N.; Rai, D. K. (Banaras Hindu Univ., India). Indian J. Pure Appl. Phys.; 10: No. 6, 418-420(Jun 1972).

The cross sections for ionization of hydrogen and nitrogen molecules and for excitation of nitrogen molecule to different ionized states have been calculated. The average of the orbital electron energies in the initial and final states has been taken as the average kinetic energy of the bound electron. M. Gryzinski's [Phys. Rev., 138A (1965), 305, 322, 336] semiclassical and L. Vriens' [Phys. Rev., 141 (1966), 88; Proc. Phys. Soc., 89 (1966), 13] exchange formulas have been used in the calculations. The results are compared with the experimental measurements and theoretical estimates due to earlier workers. (auth)

**23255** KINETICS OF ION-INDUCED ELECTRON EMISSION IN THE BOMBARDMENT OF SILICON BY NOBLE-GAS IONS IN THE ENERGY RANGE 1.5 TO 25 KeV. Gaworzewski, P.; Krebs, K. H.; Mai, M. (Humboldt Univ., Berlin). J. Mass Spectrom. Ion Phys.; 10: No. 4, 425-435(Feb 1973). (In German).

Electron yields are measured when a Si-(111)-surface is bombarded with $He^+$, $Ne^+$, $Ar^+$ and $Kr^+$ ions in the energy range 1.5 to 25 keV. It is shown that, as in the case of metallic targets, the electron yield is strongly dependent on the coverage of the surface. The surfaces are cleaned by means of ion-etching in an ultra high vacuum. In the case of atomically clean surfaces measurements are made at a residual pressure of 1 to $5 \times 10^{-10}$ torr. The magnitudes of the electron yields are analogous to those of atomically clean metal surfaces. The kinetic electron yield $\gamma_k$ increases with the velocity $u_0$ of the bombarding ions according to the relation $\gamma_k \sim u_0^q$, with $0.6 \leqq q \leqq 1.8$, depending on the kind of ions. In the case of constant ion velocities $\gamma_k$ increases nonmonotonously with increasing atomic number of the bombarding ions. (auth)

**23256** ION-MOLECULE REACTIONS IN THE $CO_2/H_2$ SYSTEM BY ION CYCLOTRON RESONANCE. Smith, D.; Futrell, J. H. (Univ. of Utah, Salt Lake City). J. Mass Spectrom. Ion Phys.; 10: No. 4, 405-418(Feb 1973).

Thermal energy rate constants have been measured for proton and hydrogen atom transfer to $CO_2$ and $CO_2^+$ from $H_2^+$ and $H_2$, respectively, using an ion cyclotron resonance mass spectrometer. At thermal energies, proton transfer is about 2.5 times more likely than electron transfer. Double resonance experiments show that the two reaction channels are of equal magnitude for an $H_2^+$ translational energy of 10 eV. At higher energies the electron transfer reaction dominates. Similar double resonance studies show that the rate constant for H transfer from $H_2$ to $CO_2^+$ is independent of $CO_2^+$ translation energy up to at least 5 eV. The most striking feature of this work is that the rate constant for proton transfer to $CO_2$ is substantially greater than the collision rate constant calculated from the usual Langevin polarization theory of ion-molecule reactions. The plausibility of this large rate constant is discussed in terms of the ion-quadrupole interaction potential. (auth)

**23257** ELECTRON IMPACT EXCITATION RATES FOR HELIUM. Benson, R. S.; Kulander, J. L. (Palo Alto Research Lab., CA). Solar Phys.; 27: No. 2, 305-318(Dec 1972).

Electron impact excitation rates are calculated for all transitions in He I and II between individual terms for $n \leq 4$. Rates calculated for a large number of different experimental, theoretical and semiempirical cross sections are compared. The rates are approximated by the expression $AT^n \exp(-\alpha E_0/kT)$ over the range $4000 \leq T \leq 50{,}000$ K for He I and $10^4 \leq T \leq 10^5$ K for He II. (auth)

**23258** PHOTOIONIZATION OF THE HELIUM METASTABLE STATES ABOVE THE $n = 2$ THRESHOLD. Jacobs, V. L.; Burke, P. G. (Queen's Univ., Belfast). J. Phys., B (London); 5: No. 12, 2272-2281(Dec 1972).

Differential cross sections for the photoelectric transitions $He(2^1S_0, 2^3S_1) + \hbar\omega \rightarrow He^+(1s, 2s, 2p, 3s, 3p, 3d) + e^-$ have been calculated for incident photon energies above the $n = 2$ threshold using Hylleraas bound state wave functions and close coupling final state wave functions. Particular attention has been given to the angular distribution of the photoelectrons ejected in the transitions to the excited states of the residual $He^+$ ion. When the partial cross sections are transformed to a representation which diagonalizes the long range $r^{-2}$ interactions coupling degenerate final state channels, it is found that some linear combination of the degenerate channels is preferentially excited over a range of incident photon energies from the threshold to several times the threshold value. At higher energies the calculated $(\sigma_{2s} + \sigma_{2p})/\sigma_{1s}$ and $(\sigma_{3s} + \sigma_{3p} + \sigma_{3d})/\sigma_{1s}$ ratios approach the asymptotic values predicted by the theory of Kabir and Salpeter (Phys. Rev.; 108: 1256-63(1957)). (auth)

**23259** S STATE RESONANCES IN ELASTIC e−H SCATTERING IN THE ABSENCE OF DEGENERACY. Rotenberg, M.; Cordes, M. R. (Univ. of California, La Jolla, San Diego). J. Phys., B (London); 5: No. 12, 2225-2230(Dec 1972).

The S state elastic scattering resonances below the $n = 2$ level of the electron-hydrogen system are investigated numerically in the 1s-2s-2p close-coupling framework. The assumption that the 2s and 2p levels of hydrogen are degenerate is dropped. Of the infinite sequence of resonances which is obtained when complete degeneracy is assumed, it is found that only five singlet and four triplet resonances remain in the presence of a 2s-2p splitting of $3.22 \times 10^{-7}$ Ryd, the approximate experimental value in hydrogen. More generally, there is a splitting which will cause any given resonance to vanish, that is, to be pushed above the hydrogen 2p level; these critical splittings are determined. In terms of the critical splittings, it is found that all shifts in resonances due an arbitrary 2s-2p splitting fall on a single universal curve. As a result, a simple recursion relation among resonances in the presence of an arbitrary splitting can be obtained. (auth)

**23260** EXCHANGE EXCITATION OF HELIUM BY ELECTRON IMPACT. Ojha, S. P.; Tiwari, P.; Rai, D. K. (Banaras Hindu Univ., India). J. Phys., B (London); 5: No. 12, 2231-2235(Dec 1972).

Cross sections for the excitation of the $2^3P$ and $3^3P$ states of helium from the ground state by electron impact are calculated using Ochkur approximation. Results are compared with various theoretical cross sections and experimental data. (auth)

**23261** RADIATION DAMPING OF ATOMIC STATES IN THE PRESENCE OF AN EXTERNAL TIME DEPENDENT POTENTIAL. Silverman, M. P.; Pipkin, F. M. (Harvard Univ., Cambridge, MA). J. Phys., B (London); 5: No. 12, 2236-2256(Dec 1972).

The problem of an atom interacting simultaneously with the quantized modes of the vacuum electromagnetic field and with a classical time dependent field is investigated utilizing the general theory of damping devised by Heitler (1954). Spectral line shapes are obtained as a function of the variables of the classical field and are studied in detail for the case of spontaneous emission from coupled levels of dissimilar lifetimes. In the limit that the time dependent coupling vanishes, the resulting spectral line is the same as that derived by Weisskopf and Wigner (Z. Phys.; 63: 54-73 and 65: 18-29(1930)). (auth)

**23262** THEORY OF ATOMIC PHOTOIONIZATION MEASUREMENTS. Jacobs, V. L. (Queen's Univ., Belfast). J. Phys., B (London); 5: No. 12, 2257-2271(Dec 1972).

The theory of photoionization measurements for a general atomic system is developed in terms of a density matrix which determines the ejected electron and residual ion polarizations as a function of the target atom and incident photon polarization states. Expressions are derived which relate the photoelectron angular distribution and spin polarization parameters to the reduced matrix elements for the photoelectric transition. These expressions incorporate the fine structure of the atomic levels and the complete interaction between the residual ion and the ejected electron. The polarization of the residual ions which are formed in excited states is treated in terms of the subsequently emitted decay radiation. (auth)

**23263** NEW APPROACH IN ATOMIC CONFIGURATION INTERACTION CALCULATIONS. Newman, D. J.; Taylor, C. D. (Queen Mary Coll., London). J. Phys., B (London); 5: No. 12, 2332-2338(Dec 1972).

A new type of potential function is derived from the atomic

Hartree-Fock self-consistent potential which has almost identical occupied orbitals, but an adjustable set of unoccupied bound orbitals. Comparisons are made between the properties of this potential and the Hartree-Fock potential for trivalent praseodymium. It is shown that the use of the new potential introduces considerable simplifications into atomic configuration interaction calculations. (auth)

**23264** PHOTOIONIZATION OF HELIUM, NEON, AND ARGON IN THE 60–230 eV PHOTON ENERGY RANGE. Watson, W. S. (Univ. of Glasgow). J. Phys., B (London); 5: No. 12, 2292-2303 (Dec 1972).

The photoionization absorption coefficients of helium, neon and argon have been measured by single beam photometry in the 60 to 230 eV photon energy range using a synchrotron radiation source and channel electron multiplier photodetection. The accuracy of most of the data is ±3% rising to ±5% for a few cases in helium. Agreement with theory is typically better than 20% for photon energies up to 150 eV with greater discrepancies at higher energies especially for helium and argon. (auth)

**23265** PHOTOIONIZATION OF $H^-$ AND He ABOVE THE $n = 2$ THRESHOLD. Hyman, H. A.; Jacobs, V. L.; Burke, P. G. (Queen's Univ., Belfast). J. Phys., B (London); 5: No. 12, 2282-2291(Dec 1972).

The photoionization cross sections of $H^-$ and $He(1^1S_0)$ have been calculated for incident photon energies above the $n = 2$ threshold using Hylleraas bound state wave functions and close-coupling final state wave functions. At low energies it is found that excitation to the 2p state of the residual atom or ion is more probable than excitation to the 2s state, a result which is in disagreement with calculations which do not include the effects of close-coupling between the final states. An analysis indicates that the relative distribution between the $n = 2$ states is determined mainly by the long-range 2s-2p dipole coupling. This is revealed by the dominance of a particular partial cross section in a representation which diagonalizes the long range $r^{-2}$ interactions coupling the degenerate $n = 2$ states. Finally, the angular distribution of the ejected electrons is calculated in the case of $H^-$. (auth)

**23266** ELECTRON-MOLECULE INTERACTIONS. 4. Scattering by Polyatomic Molecules. Burke, P. G. (Queen's Univ., Belfast); Chandra, N.; Gianturco, F. A. J. Phys., B (London); 5: No. 12, 2212-2224(Dec 1972).

The theory of scattering of low energy electrons by closed shell polyatomic molecules is developed. Coupled inhomogeneous differential equations are obtained describing the motion of the scattered electron in the fixed nuclei approximation. The symmetry group of the molecule is used to reduce these equations to their simplest form and expressions for the total, differential and momentum transfer cross sections are obtained. A transformation to the laboratory frame is then derived and this is used to obtain expressions for the rotational excitation cross sections in terms of the S matrix calculated in the fixed molecular frame. Special emphasis is given to the $C_{2v}$ and $O_h$ symmetry groups and the equations describing electron scattering by water molecules are discussed in some detail. (auth)

**23267** LONG-RANGE INTERACTIONS IN ELECTRON SCATTERING. The Threshold Law for $n \rightarrow n + 1$ Transitions. Bottcher, C. (Univ. of Manchester, Eng.). J. Phys., B (London); 5: No. 12, 2199-2211(Dec 1972).

A theory is developed of the process $e + H(n_p l_p) \rightarrow e + H(n_q l_q)$ making exact allowance for the long-range dipole interactions. It is is predicted that at threshold the cross section $Q(n \rightarrow n + 1) \sim n^6$ $(n \leq 33)$ and $n^5$ $(n > 33)$ while at sufficiently high energies the more familiar law $Q(n \rightarrow n + 1) \sim n^4 \ln n$ is recovered. The threshold behavior has some effect on thermal reaction rates for $n \sim 20$. (auth)

**23268** BOUND STATE TO CONTINUUM COLLISIONAL PROBABILITIES. II. Morse Oscillators. Lin, J. (Boston Coll., Chestnut Hill, Mass.). Physica; 62: No. 3, 369-378(1 Dec 1972).

The study of the bound state to continuum collisional transition probabilities is extended to the case of Morse oscillators using a distorted-wave Born approximation. The theory is applied to the system $X + Y_2$, where X = He, Ar and Y = H, D. It is found that for such a system, temperature plays a more important role in causing dissociation than the total energy. The result also indicates that for a Morse oscillator vibrational energy is more effective in dissociation than translational energy. (auth)

**23269** POLARIZATION STUDIES USING THE ELECTRON PHOTON COINCIDENCE TECHNIQUE. King, G. C. M.; Adams, A.; Read, F. H. (Univ. of Manchester, Eng.). J. Phys., B (London); 5: No. 12, L254-L257(Dec 1972).

A new coincidence technique has been used to study the polarization of radiation from atoms excited by electron impact. The measured polarizations are as predicted theoretically, in contrast with results obtained by the older "threshold polarization" technique. The present coincidence technique can be extended to study details of excitation mechanisms. (auth)

**23270** COMMENT ON THE "EXCITATION FUNCTIONS FOR THE FORMATION OF METASTABLE HELIUM AND ARGON BY ELECTRON IMPACT". Shearer-Izumi, W. (CEN de Saclay, Gif-sur-Yvette, France). J. Phys., B (London); 5: No. 12, L253(Dec 1972).

The purpose of this note is to call attention to the fact that the recent results of Lloyd et al (J. Phys. B: Atom. Molec. Phys.; 5: 1712-8(1972)) were incorrectly compared with those of Kupriyanov (Opt. Spectrosc.; 20: 85-6(1966)) and that they can be more suitably compared with those of Dorrestein (Physica; 9: 447-59 (1942)) and of Hotop and Niehaus (Z. Phys.; 215: 395-407(1968)). (auth)

**23271** RECOMBINATION OF $H^+$ AND $H^-$ IONS IN SLOW COLLISIONS. Janev, R. K. (Inst. of Physics, Belgrade); Tancic, A. R. J. Phys., B (London); 5: No. 12, L250-L252 (Dec 1972).

The process of recombination of positive and negative hydrogen ions is considered at low energies. The exchange interaction in $(H^+,H^-)$ system at the relevant pseudo-crossing points is found asymptotically exactly. In the cross section calculations of the process account was taken for the exponential character of this interaction and nondivergency of the potential energy curves at infinity. (auth)

**23272** NOTE ON THE OFF-SHELL COULOMB T MATRIX. 3. Inelastic e–H Differential Cross Sections. Hutton, N. A. (Univ. of Stirling, Scotland). J. Phys., B (London); 5: No. 12, L246-L249(Dec 1972).

Inelastic e–H differential cross sections are evaluated using the theory of previous work (Hutton and Roberts, J. Phys. B: Atom. Molec. Phys.; 5: L104-6(1972)). The results compare well with the angular and energy distributions of the Coulomb projected Born approximation confirming the discrepancy with the Born. The ambiguities in the absolute value of the differential cross section which were found for elastic scattering are still evident for the inelastic case. (auth)

**23273** HIGH RESOLUTION OF K X-RAY SPECTRUM OF 30 MeV CHLORINE ION BEAM. Moore, C. F.; Wolter, H. H.; Kauffman, R. L.; (and others). (Univ. of Texas, Austin). J. Phys., B (London); 5: No. 12, L262-L264(Dec 1972).

The K x-ray spectrum from a 30-MeV chlorine ion beam was measured as it was stopped in aluminum. The spectrum exhibits six lines located approximately half way between the $K\alpha_{1,2}$ and $K\beta_{1,3}$ lines of chlorine. These lines can be interpreted ad $K\alpha$ transitions with various 2p shell vacancies and with the M shell electrons partially stripped. (auth)

**23274** $H_3$ POTENTIAL SURFACE IN NATURAL COLLISION COORDINATES. Jackson, J. L.; Wyatt, R. E. (Univ. of Texas, Austin). Chem. Phys. Lett.; 18: No. 2, 161-165(15 Jan 1973).

Potential energy contour maps of the ground and electronically excited Porter–Karplus $H_3$ surfaces are presented. These maps are correlated with another set of figures showing molecular geometries. Particular attention is paid to the intersection of these electronic surfaces along the Jahn–Teller ridge. A difficulty with natural coordinates, "nonlinear schizophrenia", is described and a simple procedure for avoiding the problem is presented. (auth)

**23275** RELATIONS FOR MOLECULAR INTEGRALS OF RELATIVISTIC INTERACTIONS. Matsuoka, O. (Univ. of Electro Communications, Tokyo). Chem. Phys. Lett.; 18: No. 2, 209-210(15 Jan 1973).

Relations are derived which connect the molecular integrals of variation of electron mass from relativity, spin–orbit interaction, orbit–orbit interaction and spin–spin interaction with the overlap, the nuclear attraction, and the electron repulsion integrals. (auth)

**23276** SCATTERING OF ALKALI IONS BY THE SURFACE OF VARIOUS METALS AND SEMICONDUCTORS. Arifov, U. O.; Khadzhimukhamedov, Kh. Kh.; Yunusov, A. I.; Abdullaev, P. (Inst. of Electronics, Tashkent). Dokl. Akad. Nauk Uzb. SSR; No. 3, 22-24(1972). (In Russian).

The scattering of $Na^-$ and $K^-$ ions by the surface of a Re target was studied in the energy range 0.2 to 4 keV. On the basis of these results, a curve was constructed showing the coefficient of ion scattering ($K^-$ at 1.6 keV) as a function of atom mass of the target: B, graphite, Si, Ti, Ni, Zr, Mo, Ba, Ta, W, and Re. The atom mass of the target plays the chief role in the scattering process, rather than the density of the target material. (KSW)

**23277** INVESTIGATIONS OF THE PROBABILITY DISTRIBUTIONS OF THE NUMBER OF ATOMIC-PARTICLE-INDUCED ELECTRONS FROM COATED SURFACES OF SOLIDS. Greupner, H. (Humboldt Univ., Berlin). J. Mass Spectrom. Ion Phys.; 10: No. 4, 437-444(Feb 1973). (In German).

Probability distributions of secondary electrons produced by bombarding coated metal surfaces with cesium and lithium ions are reported. The empirical distributions are described mathematically using negative binomial and Poisson distributions and, in one particular case, a positive binomial distribution. Owing to the coating of the surfaces, a systematic dependence of theoretical distributions on physical parameters is not found. It is possible to describe the distribution of the specially normalized relative variances of the empirical probability distributions by means of a gamma distribution. Thus statistical predictions can be made about the parameters and shape of the empirical probability distributions that are expected in the case of electron release from coated surfaces due to bombardment with atomic particles. (auth)

**23278** RELATIVE BOND STRENGTHS IN ION—MOLECULE CLUSTERING REACTIONS. Good, A. (Univ. of Ceylon, Peradeniya). J. Mass Spectrom. Ion Phys.; 10: No. 4, 379-384(Feb 1973).

A semi-empirical rate expression has been used to calculate the bond dissociation energies of ion—molecule clusters from their experimentally observed third order rate constants. The agreement between theory and experiment is sufficiently good to enable the estimation of unknown bond dissociation energies by this method, with some reservations in the case of negative ions. (auth)

**23279** PROGRAM FOR NORMALIZED MORSE FUNCTIONS. Parkinson, J. R.; Birtwistle, D. T. (Polytechnic, London). Comput. Phys. Commun.; 4: No. 2, 257-261(Nov 1972).

The computer program MORSEFNS written in FORTRAN for the ICL 1905 E computer is described for normalized eigenfunctions of the Schroedinger equation with the Morse potential for molecules. (JFP)

**23280** EVALUATION OF INTEGRALS REQUIRED IN SCATTERING THEORY. II. Exchange Type Integrals. Lyons, J. D.; Nesbet, R. K. (IBM Research Labs., San Jose, CA). J. Comput. Phys.; 11: No. 2, 166-189(Feb 1973).

The presentation of methods for evaluation of integrals required in electron—atom scattering is concluded using an analytic basis set. Methods are presented for the calculation of exchange integrals between spherical Bessel functions and exponential functions. For reasons of relative speed and applicability, six different methods are presented. Features of each are discussed, and a scheme is described for selecting the most desirable method for a given case. (auth)

**23281** ATOMIC SCATTERING FACTORS FOR HEAVY ATOMS AS INVESTIGATED BY SMALL-ANGLE GAS ELECTRON DIFFRACTION. Kimura, M.; Konaka, S.; Kashiwabara, K.; Nagashima, M. (Hokkaido Univ., Sapporo). Chem. Phys. Lett.; 18: No. 4, 540-543(15 Feb 1973).

The experimental examination of the elastic and inelastic scattering factors for tin, iodine, and mercury has been performed through the total-intensity measurement of 42-keV electrons scattered by $Sn(CH_3)_4$, $ICH_3$, and $Hg(CH_3)_2$ at small angles. (auth)

**23282** MECHANSISM OF VIBRATIONAL RELAXATION OF NO UPON COLLISIONS WITH Ar. Andreev, E. A.; Umanskii, S. Ya.; Zembekov, A. A. (Inst. of Chemical Physics, Moscow). Chem. Phys. Lett.; 18: No. 4, 567-569(15 Feb 1973).

The vibrational relaxation of NO diluted in Ar is considered. The conventional adiabatic channel and the nonadiabatic vibronic channel of vibrational deactivation are taken into account. The latter appears because of the degeneracy of the electronic state of NO. It is found that the nonadiabatic channel gives the main contribution to the vibrational deactivation probability for temperatures below 2200°K. (auth)

**23283** THEORY FOR THE INTERACTIONS BETWEEN CLOSED SHELL SYSTEMS. Rae, A. I. M. (Univ. of Birmingham, Eng.). Chem. Phys. Lett.; 18: No. 4, 574-577(15 Feb 1973).

A recent theory for intermolecular interactions is modified by the exclusion of a "self-exchange" contribution and the inclusion of dispersive interactions. Improved agreement with experimental measurements of rare gas interaction potentials is obtained. (auth)

**23284** COLLISION-INDUCED DISSOCIATION: DIFFERENTIAL ENERGY TRANSFER PROBABILITIES. Eckelt, P.; Korsch, H. J. (Univ., Muenster, Ger.). Chem. Phys. Lett.; 18: No. 4, 584-588(15 Feb 1973).

Emphasizing dissociation, the energy transfer $\Delta\epsilon$ to a diatomic Morse oscillator in state n by collision with an atom is treated in a one-dimensional model. The quantum-mechanical impulse approximation yields a closed analytic expression for the differential transfer probability $P_n(\Delta\epsilon)$. Except for unessential distortions, the shape of the $P_n(\Delta\epsilon)$ distributions is a representation of the momentum distributions of the initial states n of the molecule. The mean energy transfer $\overline{\Delta\epsilon}$ is discussed as a function of the internal energy of the molecule and of the kinetic collision energy. (auth)

**23285** THRESHOLD ELECTRON IMPACT EXCITATION OF ACETYLENE. Dance, D. F.; Walker, I. C. (Univ. of Stirling, Scotland). Chem. Phys. Lett.; 18: No. 4, 601-603(15 Feb 1973).

Threshold electron energy loss spectra for acetylene are presented and assignments suggested for the excitation processes occurring. (auth)

**23286** DETACHMENT CROSS SECTIONS FOR $He^-$ IONS. Snyder, R. (Queen's Univ., Belfast). J. Phys., B (London); 6: No. 1, L8-L10(Jan 1973).

Electron detachment cross sections for $He^-(1s2s2p\ ^4P)$ ions in He, $H_2$, and Ar target gases are obtained from the classical impulse approximation method of Bates and Walker (Planet. Space Sci.; 14: 1367-73(1966) and Proc. Phys. Soc.; 90: 333-6(1967)) and compared with other experimental measurements. (auth)

**23287** CLASSICAL CROSS SECTIONS FOR COLLISIONS BETWEEN ELECTRONS AND HYDROGEN ATOMS AT INTERMEDIATE ENERGIES. Percival, I. C. (Joint Inst. for Astrophysics, Boulder, CO). J. Phys., B (London); 6: No. 1, 93-104 (Jan 1973).

Classical cross sections for collisions between electrons and highly excited atoms of ionization energy U are calculated for incident electron energies E in the range $U/4 \le E \le 4U$ and energy transfers down to 0.02U. The orbit integration or Monte Carlo method is used, and most statistical errors for the important energy transfers are of order 3% or less. The cross sections are needed for an understanding of recombination lines emitted from cool interstellar regions. Final classical states of the individual collisions have been recorded on magnetic tape for future use. (auth)

**23288** THEORETICAL STUDY OF FAST PROTON-ATOMIC HYDROGEN SCATTERING. Baye, D.; Heenen, P. H. (Univ., Brussels). J. Phys., B (London); 6: No. 1, 105-113(Jan 1973).

The diagonalization method is used to study proton-hydrogen scattering. A second order approximation is introduced and its results compared with close-coupling ones. The improvement brought with respect to first order calculation seems to be very important. Calculations including twenty states are performed. The cross sections evaluated by various theoretical methods for 1s-2s transition are compared. The cross sections obtained for d and f states are very different from those found with the Born approximation. Polarizations of 3d-2p and 2p-1s lines are also calculated. (auth)

**23289** INCOHERENT SCATTERING OF 279 keV GAMMA RAYS BY K-SHELL ELECTRONS. Murty, D. S. R.; Govindareddy, V.; Narasimhacharyulu, E. (Osmania Univ., Hyderabad, India). J. Phys., A (London); 6: No. 2, 265-271(Feb 1973).

The differential scattering cross section of 279-keV gamma rays incoherently scattered by the K-shell electrons of tungsten and erbium are experimentally determined and expressed in terms of the free electron scattering cross section. Two scintillation spectrometers and a fast-slow coincidence circuit are employed. The scattered gamma ray spectrum is displayed on a twenty channel analyzer. The experimental results are compared with those computed on the basis of different theories and the other available experimental values. (auth)

**23290** SIMPLIFIED MODEL FOR THE SCATTERING OF ZERO ENERGY ELECTRONS BY HELIUM ATOMS. Houston, S. K. (Univ. of Sheffield, Eng.). J. Phys., B (London); 6: No. 1, 131-135(Jan 1973).

A local effective potential, $H_{ex}$, is used to account for electron exchange, together with a model hamiltonian for the helium atom in Kohn's variational approximation to the electron helium scattering length, a. $H_{ex}$ was chosen to give agreement with the Born-exchange and static-exchange approximations. Correlation was introduced in the 84 term trial function by using interelectronic coordinates. The method provides an upper bound to the "model" scattering length and the value $1.16a_0$ is obtained in good agreement with more elaborate calculations and with experiment. (auth)

**23291** VARIATIONAL CALCULATIONS OF THE POSITRON—HELIUM SCATTERING LENGTH USING APPROXIMATE TARGET WAVEFUNCTIONS. Houston, S. K. (Univ. of Sheffield, Eng.). J. Phys., B (London); 6: No. 1, 136-145(Jan 1973).

Peterkop and Rabik (J. Phys. B. Atom. Molec. Phys.; 4: 1440-9 (1971)) have calculated the positron hydrogen scattering length using an inexact target wavefunction in Kohn's variational method. They showed that the usual minimum principle is violated. In this work Kohn's variational approximation to the scattering length is derived when the trial function includes an approximation to the target wavefunction. In addition calculations are reported of the positron helium scattering length in which several different approximations to the helium ground state wavefunction have been used. The results of Peterkop and Rabik are confirmed and reference is made to the "method of models" which recovers the minimum principle of Kohn's variational method. A suggestion for extending this method to electron helium collisions is included. (auth)

**23292** MEASUREMENTS OF CROSS SECTIONS FOR THE IONIZATION OF $Ba^+$ BY ENERGY RESOLVED ELECTRONS. Peart, B.; Stevenson, J. G.; Dolder, K. T. (Univ. of Newcastle upon-Tyne, Eng.). J. Phys., B (London); 6: No. 1, 146-149(Jan 1973).

The crossed beam method for observing the ionization of ions by electrons has been refined by the inclusion of a 127° electrostatic electron energy selector. This enhances the resolution of the measurements, by an order of magnitude, to about 0.15 eV. With this apparatus, autoionization thresholds have been resolved in the ionization function for, $Ba^+ + e \rightarrow Ba^{2+} + 2e$, at energies of 15.8, 16.8, 19.2, and 21.9 eV. Observations have also been made of the near-threshold ionization of $K^+$. (auth)

**23293** COLLINEAR COLLISION OF AN ATOM AND A MORSE OSCILLATOR. Exact Quantum mechanical Results. Clark, A. P.; Dickinson, A. S. (Univ. of Stirling, Scotland). J. Phys. B (London); 6: No. 1, 164-180(Jan 1973).

Exact quantum mechanical vibrational transition probabilities are obtained for a collinear atom-diatomic molecule collision using the reactance matrix K. Both the Morse and harmonic binding potentials are considered and it is shown that the transition probabilities for the Morse oscillator may differ considerably from the equivalent harmonic oscillator results. The exact transition probabilities are compared with those of several approximate theories, and it is shown that the revised first order distorted wave approximation of Mies (J. Chem. Phys.; 40: 523-31(1964)) is valid, provided that the scaled reduced mass (m) of the incident atom is not large. (auth)

**23294** DEPENDENCE OF SYMMETRICAL CHARGE TRANSFER CROSS SECTION ON IONIZATION POTENTIAL. Dewangan, D. P. (Saha Inst. of Nuclear Physics, Calcutta). J. Phys., B (London); 6: No. 2, L20-L23(Feb 1973).

Within the framework of the impact parameter method in the two-state approximation, it is shown that the symmetrical charge transfer cross section at a given impact velocity is inversely proportional to the ionization potential of the atom. (auth)

**23295** CHARGE EXCHANGE IN $Li^+$–He COLLISIONS. Lesech, C. (Observatoire de Paris, Meudon, France); McCarroll, R.; Baudon, J. J. Phys., B (London); 6: No. 2, L11-L14(Feb 1973).

It is proposed that charge exchange in $Li^+$–He collisions in the keV energy range takes place mainly via rotational coupling of the $^1\Sigma$ and $^1\Pi$ states of the $LiHe^+$ quasi-molecule. The potential energy curves of the $^1\Sigma$, $^1\pi$, and $^1\Delta$ states are calculated by a perturbation method for small internuclear distances. Using these curves, the differential scattering cross sections for excitation and charge transfer are calculated. Agreement with experiment is satisfactory for $E\theta$ exceeding 7 keV degree. (auth)

**23296** DISSOCIATIVE PHOTOIONIZATION OF $H_2$ AND $D_2$ THROUGH THE $1s\sigma_g$ IONIC STATE. Browning, R.; Fryar, J. (Queen's Univ., Belfast). J. Phys., B (London); 6: No. 2, 364-371(Feb 1973).

The dissociative photoionization of $H_2$ and $D_2$ has been investigated experimentally and theoretically from just below threshold to 30.5 eV (405 Å). Experimentally the ratios of the number of dissociated to undissociated photoions $H^+/H_2^+$, $D^+/D_2^+$ have been determined using a mass spectrometric system essentially free from discrimination against ion species. These ratios are found to rise to plateau values of $0.0208 \pm 0.0017$ and $0.0082 \pm 0.0008$ respectively. Over most of the energy range investigated, the photoions are formed solely through the $1s\sigma_g$ ionic state, permitting approximate calculations to be made. A comparison between the calculated and experimental results indicates the need for improved calculations. Significant differences are found on comparing the photoionization data reported with the corresponding values obtained by particle impact. (auth)

**23297** INELASTIC COLLISION OF FAST CHARGED PARTICLES WITH ARBITRARY LEVELLED HYDROGEN-LIKE ATOMS. Omidvar, K.; Khateeb, A. H. (Univ. of Teheran). J. Phys., B (London); 6: No. 2, 341-353(Feb 1973).

In collision of the charged particles with neutron atoms when the relative incident momentum is some ten times or more larger than the momentum of the target electron, the inelastic cross section can be expressed in terms of the incident energy and two atomic parameters, called the Bethe coefficients. In the case of the total inelastic cross section of the hydrogen-like atoms in a given initial state these coefficients in the forms of sums and integrals have been found, and for the first seven principal quantum numbers they are evaluated numerically. For these quantum numbers as the initial states a table of the Bethe coefficients for all possible excitations, ionizations and the total inelastic cross sections is given. An asymptotic formula for the total inelastic cross section for arbitrary large excited states is also given. A table published by Bethe and Salpeter (1957) for the electric dipole matrices between hydrogen-like states does not have the proper normalization. This normalization has been performed and a new table for these matrices is presented. (auth)

**23298** ELECTRON SCATTERING BY ATOMIC HYDROGEN USING A PSUEDO-STATE EXPANSION. 4. The Convergence of the S-State Expansion at Intermediate Energies. Burke, P. G.; Mitchell, J. F. B. (Queen's Univ., Belfast). J. Phys., B (London); 6: No. 2, 320-328(Feb 1973).

The convergence of the pseudo-state expansion of the electron hydrogen atom system at intermediate energies is studied. The atomic 1s and 2s eigenstates as well as $\overline{3s}$, $\overline{4s}$, and $\overline{5s}$ pseudostates are retained in the expansion and calculations in the singlet L = 0 state are carried out over incident electron energies from 10.2 eV to 30.6 eV. The 1s-2s excitation cross section is found to converge rapidly, except in the region of certain nonphysical resonances, and this result is used to estimate the accuracy of earlier work using the pseudo-state expansion. (auth)

**23299** ELASTIC SCATTERING OF SLOW ELECTRONS BY HELIUM. Knowles, M.; McDowell, M. R. C. (Royal Holloway Coll., London). J. Phys., B (London); 6: No. 2, 300-313(Feb 1973).

The optical potential model of Pu and Chang (Phys. Rev.; 151: 31-40(1966)) is extended to include EPV diagrams. Calculations are carried out for the s, p, and d wave phase shifts at energies up to 17 eV. The results for s and p waves are in close agreement with those of other recent calculations and, with a phase shift analysis of experimental data. The d wave results lie between the full polarized orbital and the Green function expansion results. It is shown that third order diagrams are required for an accurate evaluation of the static polarizability, yielding $\alpha = 1.372\ a_0^3$, and estimates are made of the third order correction to the d wave phase shift, which brings the optical potential values into good agreement with the full polarized orbital results. (auth)

**23300** THRESHOLD BEHAVIOR OF e-H COLLISIONAL EXCITATION FUNCTION. Classical Treatment. Grujic, P. (Inst. of Physics, Belgrade). J. Phys., B (London); 6: No. 2, 286-299 (Feb 1973).

The excitation $n = 1 \rightarrow n = 2$ interval probability function for e-H collisions has been examined using a classical model. The electron-hydrogen atom long range interaction has been accounted for via a static dipole potential of the atom, and electron motion in the atomic dipole field has been examined analytically. The results obtained are used for initiations of numerical calculations in the close interaction region. A three body classical computer program by Abrines et al (Proc. Phys. Soc.; 89: 515-23(1966)) has been used for the numerical calculations. The initial atomic orientation interval function per unit final energy band of the atom, for the total angular momentum L = 1.665 au (plane case) has been evaluated in the energy range; $0.378 \le E$ (au) $\le 0.411$. The function obtained shows an oscillatory behavior with two maxima at approximately 0.381 and 0.390 au. A comparison with existing experimental data and quantum mechanical results is made. (auth)

**23301** DOUBLE IONIZATION BY ELECTRON IMPACT. 2. Calculations of Cross Sections for $H^-$, He, and $Li^+$. Tweed, R. J. (University Coll., London). J. Phys., B (London); 6: No. 2, 270-285(Feb 1973).

The Born I and Born II approximations are discussed in the context of double ionization, and their behavior at high energy compared with experiment. The Born I approximation, excluding exchange, is used to calculate total and partial cross sections for the double ionization of $H^-$, He and $Li^+$, with various approximations used for the final state of the system, some of these being found to give good agreement with experiment. (auth)

**23302** DOUBLE IONIZATION BY ELECTRON IMPACT. 1. General Theory. Tweed, R. J. (University Coll., London). J. Phys., B (London); 6: No. 2, 259-269(Feb 1973).

Using the Schrödinger equation as a starting point, the asymptotic form of the wave function is derived for a collision involving double ionization by electron impact, and expressions are obtained for the total and partial cross section. The effect of including exchange is also considered both for singlet and triplet spin states of the target atom. (auth)

**23303** COMPARISON OF THE SECOND BORN APPROXIMATION USING PLANE-WAVE AND FINAL-STATE GREEN FUNCTIONS. Holt, A. R.; Santoso, B. (Univ. of Essex, Eng.). J. Phys., B (London); 6: No. 2, 254-258(Feb 1973).

In calculations, with the second Born approximation, of cross sections for the scattering of electrons or protons by atoms two different Born expansions have been used. For direct processes work so far has used an expansion in terms of the final-state Green function, whereas for rearrangement collisions, the plane-wave Green function has mainly been used. In this work a comparison is made between the second Born approximations for a direct process when both approximations can be exactly evaluated—the elastic scattering of electrons or protons by hydrogen atoms in the forward direction. (auth)

## Atomic Theory

**23304** (JINR-E4-6903) VIRIAL THEOREM IN ADIABATIC REPRESENTATION. Matveenko, A. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1973. 10p. Dep. NTIS (U. S. Sales Only) $3.00.

For any diatomic molecule three different virial theorems can be formulated. The most general one is independent of the problem and the representation. The other two stem out of adiabatic representation. The first of them is well known electronic Slater's virial theorem. We have derived the virial theorem from the Born–Oppenheimer type coupled nuclear equations. (auth)

**23305** UPPER-BOUND PROPERTY OF SECOND DERIVATIVES OF THE ENERGY. Deb, B. M. (Indian Inst. of Tech., Bombay). Chem. Phys. Lett.; 17: No. 1, 78-103(1 Nov 1972).

An easy alternative proof is provided for the upper bound relation $(\partial^2 E/\partial\lambda^2)\ \langle\Psi|\Psi\rangle \leq \langle\Psi|\partial^2 H/\partial\lambda^2|\Psi\rangle$. Like an earlier proof by Silverman and van Leuven the present approach presupposes the validity of the Hellmann–Feynman (H–F) theorem. (auth)

**23306** ATOMIC ENERGY CALCULATION BY A MODIFIED STATISTICAL THEORY. Apagyi, B. (Research Group for Theoretical Physics, Budapest). Acta Phys. Acad. Sci. Hung.; 33: No. 1, 23-31(1973).

A modified Thomas–Fermi equation proposed by Gombás is solved. The total energies calculated for representative atoms of the periodic system are in good agreement with the experimental values. The role of the modifying term is illustrated. (auth)

**23307** VECTOR COUPLING COEFFICIENTS AS PRODUCTS OF PRIME FACTORS. Dodds, R. McD.; Wiechers, G. (Univ. of Port Elizabeth, South Africa). Comput. Phys. Commun.; 4: No. 2, 268-274(Nov 1972).

The computer program COEF written in FORTRAN IV for the ICL 1901A computer is described for the computation of 3j and 6j symbols and rotation matrices expressed as a product of powers of prime numbers for the angular momentum vector coupling coefficients for atomic and nuclear physics. (JFP)

**23308** EMPIRICAL EFFECTIVE PARAMETERS OF ATOMS. Markov, P. J. (Univ., Sofia). Compt. Rend. Acad. Bulg. Sci.; 25: No. 12, 1633-1636(1972).

An attempt is made to calculate the effective parameters of hydrogen-like multielectron atoms on the basis of the experimentally observable ionization potential and atomic radius. (JFP)

**23309** EXTRAPOLATION IN ITERATIVE SEQUENCES. Neilsen, W. B. (Univ. of Kansas, Lawrence). Chem. Phys. Lett.; 18: No. 2, 225-230(15 Jan 1973).

The convergence of a general iterative sequence, each member of which is a set of numbers, is analyzed. An effective method of extrapolation is suggested, and tested on some Hartree–Fock SCF iterative sequences. (auth)

**23310** PERTURBATION ANALYSIS OF CURRENT METHODS OF CALCULATING RELATIVISTIC ENERGIES. Ermolaev, A. M.; Jones, M. (University Coll., London). J. Phys., B (London); 6: No. 1, 1-22(Jan 1973).

The principal methods of calculating relativistic corrections are analysed from the point of view of the relativistic perturbation theory. The conditions under which the Breit–Pauli method is consistent with the relativistic perturbation method of Layzer and Bachall (Ann. Phys. NY; 17: 177-204 (1962)) are formulated. Difficulties arising in the application of perturbation expansions in terms of 1/Z to relativistic Hartree–Fock equations are demonstrated. Some typical numerical data are examined in the light of these discussions. (auth)

**23311** CRITICAL REVIEW OF PROGRAMS IN ATOMIC STRUCTURE FOR BOUND STATES. Froesce Fischer, C. (Univ. of Waterloo, Ont.). Comput. Phys. Commun.; 5: No. 2, 147-152(Feb 1973).

Programs in the Computer Physics Communications library for the calculation of atomic structure properties of bound states are summarized. Some of the difficulties encountered in implementing many of these programs are mentioned, and suggestions are made for improvement of both the program and the published write-up. (auth)

# PHYSICS (ELECTROFLUID AND MAGNETOFLUID)

*Refer also to abstract 22341.*

**23312** LINEAR OSCILLATORY HYDROMAGNETIC FLOW BETWEEN TWO COAXIAL CYLINDERS. Gupta, P. R.; Arora, K. L. (Punjab Engineering Coll., Chandigarh, India). J. Math. Anal. Appl.; 41: No. 3, 716-724(Mar 1973).

Hydromagnetic flow between two coaxial circular cylinders is discussed when the inner cylinder oscillates axially under a radial magnetic field. Exact solution is given for the case of a perfectly conducting fluid. Expressions for velocity, induced magnetic field, current density, electric field, viscous drag and energy transfer are derived and expressed in polar forms so as to facilitate the study of magnitude and phase variations. Current sheets are found to exist on the two boundaries. (auth)

**23313** SOME POTENTIAL FUNCTIONS IN MAGNETOHYDRODYNAMICS. Vacca, M. T. Atti Accad. Naz. Lincei, Rend., Cl. Sci. Fis., Mat. Natur.; 52: No. 3, 357-366(Mar 1972). (In Italian).

An incompressible viscous indefinite and electrically conductive fluid slowly moving under the action of a uniform magnetic field and body forces distributed with continuity in a fixed region of the medium are considered. Two procedures for reduction of this problem are given. In the case where the induced magnetic field is sufficiently small compared with the body forces, solutions of the velocity field, induced magnetic field and pressure field are determined. These solutions are expressed by definite integrals which, having an analogy with the Newtonian volume potentials, are called hydrodynamic and magnetic potentials. (auth)

**23314** SOME EXTREMUM PRINCIPLES FOR PIPE FLOW IN MAGNETOHYDRODYNAMICS. Smith, P. (Univ. of Keele, Eng.). Z. Angew. Math. Phys.; 23: No. 5, 753-764(1972).

Some extremum principles for magnetohydrodynamic pipe flow are presented and these are used to obtain bounds for the flow-rate in the pipe. It is shown how asymptotic expansions for the flow-rate at large Hartmann number can be constructed. The method is applied to rectangular pipes and certain pipes of arbitrary cross-section. (auth)

**23315** UNSTEADY MHD FREE CONVECTION FLOW PAST AN INFINITE VERTICAL FLAT PLATE WITH VARIABLE SUCTION. Soundalgekar, V. M. (Indian Inst. of Tech., Bombay). Indian J. Pure Appl. Math.; 3: No. 3, 426-436(May 1972).

An analysis of the effects of a variable suction and the horizontal magnetic field on the free convective flow past infinite, vertical, porous plate was carried out. Approximate solutions for the velocity, fluctuating parts of the velocity, amplitude and phase of the skin friction are obtained. This is followed by a detailed comparative discussion of different parameters on the free convective flow of mercury and ionized air. (auth)

**23316** ESR INDUCED TRANSITIONS IN SUPERCONDUCTING DILUTE MAGNETIC ALLOYS. Chaikin, P. M. (Univ. of California, Los Angeles). Solid State Commun.; 12: No. 1, 35-38 (1 Jan 1973).

By varying the microwave power absorbed by a magnetic impurity at resonance it is possible to change the effective spin temperature and hence both the magnetization and conduction electron scattering from the impurity. Since both the magnetization and scattering contribute to the pairbreaking in a superconductor, the application of a strong ESR field can induce either a normal metal superconducting or a superconductor normal depending on the selected properties of the alloy system. (auth)

**23317** STEADY ROTATION OF MHD FLUID WITHIN A CYLINDRICAL ANNULUS. Banerjee, S. K.; b (Rishi Bankim Chandra Coll., Naihati, India). Indian J. Phys.; 46: No. 6, 265-170(Jun 1972).

The fundamental equations of hydrodynamics and electromagnetic equations were utilized to solve the problem of steady rotation of a conducting liquid within a cylindrical channel under the influence of a radial magnetic field. The liquid under consideration is assumed to be viscous, incompressible and that Lorentz Force is the only body force in the fluid. The problem presented here is of engineering importance in the theory of lubrication. (auth)

**23318** NONLINEAR HYDRODYNAMIC AND HYDROMAGNETIC SPIN-UP DRIVEN BY EKMAN–HARTMANN BOUNDARY LAYERS. Benton, E. R. J. Fluid Mech.; 57: No. 2, 337-360(6 Feb 1973).

Finite amplitude, impulsively started spin-up and spin-down is analysed for axially symmetric flow of a viscous, incompressible, electrically conducting fluid confined between infinite, flat, parallel, insulating boundaries. A uniform axial magnetic field is present in the initial state, but is subsequently distorted by fluid motions. The method of matched asymptotic expansions reduces the problem to a first-order, ordinary, nonlinear, integro-differential equation for the transient development of the interior angular velocity on the time scale of spin-up, as driven by quasi-steady nonlinear Ekman–Hartmann boundary layers. This two-parameter equation is solved analytically in certain limits and numerically in general. The solutions show that nonlinear non-magnetic spin-up and spin-down take longer than for linearized flow, spin-down occurring more rapidly in the early stages but requiring more time for completion than spin-up. A magnetic field promotes both spin-up and spin-down, but a weak field is relatively ineffective for spin-down yet very effective for spin-up. A strong magnetic field dominates non-linear processes and gives identical spin-up and spin-down times, which coincide with that found from linear hydromagnetic theory. (auth)

**23319** FLOW OF A CONDUCTING FLUID IN A CYLINDRICAL DUCT WITH PERIODIC DEFORMATIONS IN THE PRESENCE OF AN AZIMUTHAL MAGNETIC FIELD. Borzeix, J.; Chagneau, F. (Univ., Poitiers, France). J. Mec.; 11: No. 4, 623-648(Dec 1972). (In French).

The MHD flow of an incompressible viscous fluid inside an insulating cylindrical duct in the presence of an azimuthal magnetic field is considered. The flow is steady and the Reynolds number is assumed to be small. A complete solution for the stream-function, the velocity, and the pressure is given for the case of small periodical variations in the wall shape. Two specific numerical examples are considered and the results are compared with those given by experiments. (auth)

**23320** HYDROMAGNETIC ROSSBY WAVES EXCITED BY TRAVELLING FORCING EFFECTS. Sarma, M. S.; Sarma, L. V. K. V. (Indian Inst. of Tech., Madras). J. Fluid Mech.; 57: No. 2, 303-320(6 Feb 1973).

The pattern and propagation of hydromagnetic Rossby waves excited by travelling forcing effects on a rotating spherical shell of incompressible, inviscid, perfectly conducting fluid are studied using Lighthill's technique. The basic magnetic field $H_0$ is assumed to be uniform and acting in the "beta-plane" in an arbitrary direction. The two situations when the forcing effects travel along and perpendicular to $H_0$ are considered. (auth)

**23321** STABILITY OF MHD WAVE. Bondyopadhaya, R. (Jadavpur Univ., Calcutta). Indian J. Phys., 46: No. 6, 281-285 (Jun 1972).

The propagation of MHD waves through a uniform incompressible viscous gravitating fluid, of finite conductivity in the presence of a uniform magnetic field is considered. The problem of stability of this wave is examined in brief. It is found that stability requires a condition which is different from Jeans' criterion when the magnetic field is present. (auth)

**23322** NON-LINEAR PROBLEM OF MAGNETIC HYDRODYNAMICS. Dorokhov, V. O.; Kolosov, A. I. (Kharkov Inst. of Radio Electronics). Dopov. Akad. Nauk Ukr. RSR, Ser. A; No. 1, 74-77(Jan 1973). (In Ukrainian).

The Dirichlet problem is considered for an elliptic nonlinear equation occurring in magnetohydrodynamics. The approximate solution of the problem is constructed. It accurately satisfies the boundary conditions. (auth)

# PHYSICS (HIGH-ENERGY)

## Particle Interactions and Properties (Experimental)

*Refer also to abstract 23233.*

### Electromagnetic

**23323** (JINR-P1-6934) MEASUREMENT OF THE PION AND NUCLEAR FORM FACTORS AT TIME-LIKE TRANSFERRED FOUR MOMENTUM VALUES OF $k^2 = 1{,}7\ f^{-2}$, $2{,}2\ f^{-2}$ AND $2{,}9\ f^{-2}$. Berezhnev, S. F.; Dem'yanov, A. V.; Kulikov, A. V.; Kuplov, A. V.; Kurochkin, V. P.; Mkrtchyan, G. G.; Nemenov, L. L.; Pustyl'nik, Zh. P.; Smirnov, G. I.; Fedunov, A. G.; Khazins, D. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1971. 19p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

The first experimental estimates of the nucleon form factor $F_1^v(k^2)$ in the time-like region were reported in paper. These estimates as well as the estimates of the pion electromagnetic form factor $F_\pi(k^2)$ were obtained at the four-momentum transfer $k^2 = 2\ f^{-2}$ from the analysis of the data on the $\pi^- p \rightarrow e^+e^-n$ reaction in the $\Delta$ (1236) resonance region. This paper represents an analysis of new data on the $\pi^- p \rightarrow e^+e^-n$ process obtained by authors. It is shown that theoretical description of the process in question in this particular region ($w = \sqrt{s} = 1296$ MeV) is much simpler than that of photo- and electroproduction processes. Both the pion electromagnetic form factor $F_\pi(k^2)$ and the isovector Dirac-nucleon form factor $F_1^v(k^2)$ were assumed to be real in this region of small four-momentum transfers: $k^2 = 1.7\ f^{-2}$, $2.2\ f^{-2}$ and $2.9\ f^{-2}$. It is shown that the model fits all experimental distributions well in assumption of equality $F_\pi(k^2) = F_1^v(k^2)$. In this assumption the values of form factors at the mentioned above four-momentum transfers are $F_\pi(k^2) = F_1^v(k^2) = 1.10 \pm 0.07$, $1.14 \pm 0.06$, $1.30 \pm 0.07$. The value of electromagnetic radius in this case is $r_\pi = r_{F_1^v} = (0.75 \pm 0.14)$ f and is consistent with the value determined in the eN elastic scattering $r_{F_1^v} = 0.82$ f. The parameters $F_\pi(k^2)$ and $F_1^v(k^2)$ being assumed independent, the determination of form factors is possible only at $k^2 = 2.9\ f^{-2}$: $F_\pi(k^2) = 1.2^{+0.2}_{-0.3}$, $F_1^v(k^2) = 1.4^{+0.1}_{-0.2}$. (auth)

**23324** (LNF-72/69) ELECTROMAGNETIC STRUCTURE OF THE HADRONS. Bartoli, B.; Felicetti, F.; Silvestrini, V. (Comitato Nazionale Per l'Energia Nucleare, Frascati (Italy). Laboratori Nazionali di Frascati). 31 Jul 1972. 59p. Dep. NTIS (U. S. Sales Only) $5.00.

A review is given of lepton elastic scattering on nucleons and virtual pions, lepton inclusive inelastic scattering on nuclear targets, and hadron–antihadron pair and multihadron system production in $e^+ + e^-$ collisions. Also experimental evidence for the validity of the hypothesis for the expression of experimental results in terms of hadronic structure functions is reviewed. (JFP)

### Weak

**23325** (ORO-4040-1) EXPERIMENT TO DETERMINE THE CHARGE STRUCTURE OF THE PROTON AT LARGE DISTANCES. Final Report. Trower, W. P. (Virginia Polytechnic Inst. and State Univ., Blacksburg). 1972. Contract AT(40-1)-4040. 14p. Dep. NTIS. $3.00.

The termination of the AEC support for this project precedes the anticipated completion of the experiment by ~ eighteen months. All the major equipment has been constructed and tested, targets fabricated and detailed estimates of the sources of error in the cross section measurements made. Absolute cross section measurements on carbon necessary for subtraction from the polyethylene data which will yield the proton's electric form factor $.01 \leq q^2 \leq 1.0\ \mathrm{fm}^{-2}$ began in the fall of 1972. (auth)

**23326** NEUTRINO '72. Volume I. Europhysics conference, Balatonfuered, Hungary, June 11-17, 1972. Frenkel, A.; Marx, G. (eds.). Budapest; OMKDK-Technoinform (1972). 377p. (CONF-720651-(Vol.1)).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972).

The conference included 26 papers for all of which separate abstracts were prepared. (JFP)

***For abstracts of individual papers see: 23147–23153, 23182–23185, 23327–23331, 23352, 23371–23374, 23535, 23542, 23550, 23632, and 23633.***

**23327** ANTINEUTRINO–ELECTRON SCATTERING. Gurr, H. S.; Reines, F.; Sobel, H. W. (Univ. of California, Irvine). pp 147-165 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

An upper limit for the cross sections for $\bar{\nu}_e + e \rightarrow \bar{\nu}_e + e$ interactions is found. (JFP)

**23328** REVIEW OF THE EXPERIMENTAL SITUATION ON NEUTRAL CURRENTS. Balty, C. (Columbia Univ., New York). pp 199-228 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

A review is given of the experimental limits and predictions of the Weinberg model for the existence of neutral currents in weak interactions. (JFP)

**23329** SEARCH FOR NEUTRAL CURRENTS IN GARGAMELLE. Aachen, Brussels, CERN, Ecole Polytechnique, Milan, Orsay, University Coll., London, pp 229-237 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

A search is made for neutral currents in $\nu$ and $\bar{\nu}$ interactions in a freon bubble chamber. The first qualitative indications and future possibilities are reported for leptonic and semileptonic neutral currents. (JFP)

**23330** MUON PHYSICS. Telegdi, V. L. (Enrico Fermi Inst., Chicago). pp 337-348 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK Technoinform (1972).

From Symposium on neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

The review of the muon covers properties, electrodynamics, decay, V–A theory, CP violation, quantum number, and the mass of the muon neutrino. (JFP)

**23331** CONCLUSIONS OF THE FIRST PART OF THE NEUTRINO '72 EUROPHYSICS CONFERENCE, BALATONFUERED. Pontecorvo, B. (Joint Inst. for Nuclear Research, Dubna, USSR). pp 349-369 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

The summary covers the $K_2 \rightarrow 2\mu$ puzzle, upper limit for solar neutrinos, lepton charge conservation upper limits, stable heavy leptons, antineutrino–electron scattering upper limit, and neutral current upper limits. Experimental work is emphasized. (JFP)

**23332** SIXTEENTH INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS. 1. Weak Interactions. Rau, R. R. (Brookhaven National Lab., Upton, NY). Comments Nucl. Particle Phys.; 5: No. 4, 107-118(Jul 1972).

Comments are offered on work reported in the field of weak interactions at the Sixteenth International Conference on High Energy Physics, University of Chicago, September 1972. Especially noteworthy were the new results from the ISR (Intersecting Storage Ring), and first results from the National Accelerator Laboratory at 100 to 300 GeV/c were also reported. In addition studies were reported from lower energy accelerators all over the world. The studies are reported under the following headings: the $K_L^0 \rightarrow 2\mu$ problem; the anomalous muon component in cosmic rays; neutrinos; and neutral currents. (UK)

### Strong (Baryon-induced)

**23333** (ANL/HEP-7249) REACTION $pp \rightarrow \gamma +$ ANYTHING AT 205 GeV AND ITS IMPLICATIONS FOR $\pi^0$ PRODUCTION. Charlton, G.; Cho, Y.; Derrick, M. (Argonne National Lab., Ill.). 1972. 10p. (CONF-720954-18). Dep. NTIS.

From 16th international conference on high energy physics; Batavia, Illinois, USA (6 Sep 1972).

From observations of photon conversions into electron pairs in the 30-inch hydrogen bubble chamber exposed to a 205-GeV proton beam at the National Accelerator Laboratory, we have measured topological and differential cross sections for the inclusive reaction $pp \rightarrow \gamma +$ anything. Comparison with data on the same reaction at the CERN ISR suggests that $\pi^0$ production in pp collisions has reached a scaling limit by 205 GeV. We find that for multiplicities up to about 12, the average number of $\pi^0$'s per inelastic pp collision increases with the number of charged particles produced. (auth)

**23334** (IFVE-ORZ-71-81) INTERNUCLEAR CASCADE IN CONCRETE SHIELDING OF THE 70 GeV PROTON SYNCHROTRON. Britvich, G. I.; Getmanov, V. B.; Lebedev, V. N.; Mal'kov, V. V.; Sychev, B. S. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1971. 15p. (In Russian). INIS.

Fundamental parameters were proposed which characterize cascade development in a concrete parallelopiped. The cascade was triggered by 30-GeV neutrons. The experimental data were compared with the results of calculations carried out by Ranft. (tr-auth).

**23335** (JINR-P1-6877) 9.4-GeV/c DEUTERON INTERACTION WITH PHOTOEMULSION NUCLEI. Bogachev, N. P.; Tolstov, K. D.; Shabratova, G. S. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1971. 18p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

Inelastic interactions of 9.4 GeV/c deuterons with photoemulsion nuclei are considered, including the multiplicity, angular distributions of secondary particles and angular correlations. (auth)

**23336** (NAL-78) pp INTERACTIONS AT 303 GeV/c: MULTIPLICITY AND TOTAL CROSS SECTION. Dao, F. T.; Gordon, D.; Lach, J.; Malamud, E.; Meyer, T.; Poster, R.; Slater, W. (National Accelerator Lab., Batavia, Ill.). 23 Oct 1972. Contract AT(49-8)-3000. 21p. Dep. NTIS.

In an exposure of the 30-in. hydrogen bubble chamber to a 303 GeV/c proton beam, 2245 interactions have been observed. The measured total cross section is 39.0 ± 1.0 mb and the average charged particle multiplicity, $\langle n_{ch} \rangle = 8.86 \pm 0.16$. (auth)

**23337** (NP-19667) STUDY OF THE REACTION $\bar{p}n \to N\bar{N}\pi$ FROM 1.0 TO 1.6 GeV/c. Bettini, A.; Cresti, M.; Mazzucato, M.; Sartori, S. (Padua Univ. (Italy). Istituto di Fisica; Istituto Nazionale di Fisica Nucleare, Padua (Italy)). Dec 1972. 24p. Dep. NTIS (U. S. Sales Only).

The reaction $\bar{p}n \to p\bar{p}\pi^-$ has been studied in the c.m. energy interval from 2.08 to 2.29 GeV. Our data exclude that the bump observed in the $\bar{N}N$ cross section for $I = 1$ at a laboratory momentum of 1.32 GeV/c is due to the production of one pion. The cross section for this reaction rises only slowly with energy after the threshold for isobar production is reached. (auth)

**23338** ESTIMATION OF THE PROTON SPECTRUM UP TO ENERGIES OF ONE GeV BY A SCINTILLATION DETECTOR. Shavrin, P. I.; Samonenko, Yu. A.; Razumov, Yu. A. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; 13: No. 5, 622-624(1972). (In Russian).

A plastic scintillator was used to obtain the spectral composition of protons, based on the dependence of the specific ionization dE/dx on the energy of the particle. The effectiveness of this method was enhanced by the use of a scintillator of such shape and dimensions as to provide a steeper distribution curve than offered by a spherical scintillator. The method is valid for protons up to ~1 GeV in energy, for which the dependence of dE/dx on energy becomes weak. (KSW)

**23339** ANGULAR DISTRIBUTION OF SHOWER PARTICLES. Azimov, S. A.; Mullazhonov, E.; Tillaev, T.; Yuldashbaev, T. S. (Physical-Technical Inst., Tashkent). Dokl. Akad. Nauk Uzb. SSR; No. 3, 25-27(1972). (In Russian).

The angular distribution of shower particles generated during the interaction of >200 GeV nucleons and pions with paraffin nuclei was investigated. The measurements were conducted at an altitude of 3200 m above sea level, using a spark chamber and Cherenkov spectrometer. The symmetry of a portion of the showers, and the azimuthal correlations in the angular distribution of the shower particles were discussed. (KSW)

### *Strong (Meson-induced)*

**23340** (INP-806, pp 1-3) COHERENT PRODUCTION ON NUCLEI BY π AND K MESONS (EXPERIMENT). Summary of Lectures. Beusch, W. (CERN, Geneva). 1972.

The review lecture briefly covers $(\pi^-, \pi^+ 2\pi^-)$, $(\pi^-, 2\pi^+ 3\pi^-)$, $(K, K2\pi)$, and $K^+$, K(890) reactions with nuclei. The experimental results are summarized. (JFP)

**23341** (JINR-P1-6906) INELASTIC $\pi^+p$ INTERACTIONS AT 230 MeV. Batusov, Yu. A.; Bunyatov, S. A.; Gulkanyan, G. R.; Sidorov, V. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1971. 18p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

The cross section of the reaction $\pi^+p \to \pi^+\pi^+n$ at $T_\pi = 230$ MeV was measured, which allows one to exclude one the most probable values of parameter $\xi$, determining the type of the interaction Lagrangian for $\pi\pi \to \pi\pi$, $\pi N \to \pi\pi N$ processes near the threshold in soft pion theory. Two possible values are found for the ratio of isotopically invariant amplitudes of the reactions $\pi N \to \pi\pi N$ on the threshold in the states $P_{11}$ and $P_{31}$. The cross sections of the reactions $\pi^+p \to \pi^+\pi^0p$ and $\pi^+p \to \pi^+\gamma p$ ($E_\gamma > 50$ MeV) at the energy $T_\pi = 230$ MeV are estimated. (auth)

**23342** (LBL-1320) MEASUREMENT OF THE POLARIZATION PARAMETER IN $\pi^{\pm}p$ SCATTERING FROM 356 TO 519 MeV/c. Gorn, W. (California Univ., Berkeley. Lawrence Berkeley Lab.). Jan 1973. Contract W-7405-eng-48. 98p. Dep. NTIS $7.00.

Thesis.

Using a polarized proton target, the polarization parameter for both $\pi^+p$ and $\pi^-p$ scattering was measured at four pion laboratory momenta: 356, 417, 468, and 519 MeV/c. The results are compared with those of other experiments, and the effects of the discrepancies between this and other experiments on the established phase shift solutions at these energies are examined. (auth)

**23343** EVIDENCE FOR AN $\omega^0\pi^+\pi^-$ DECAY MODE OF THE $A_2^0$ VIA AN $\omega^0\pi^{\pm}$ RESONANCE AT 1040 MeV AND FOR AN $\omega^0\pi^+\pi^-$ EFFECT NEAR 1400 MeV. Defoix, C.; Dobrzynski, L.; Espigat, P.; Nascimente, A.; O'Neall, J.; Rivet, P.; Siaud, J. (College de France, Paris). Phys. Lett., B; 43B: No. 2, 141-145(22 Jan 1973).

Three enhancements are observed in the final state $\omega^0\pi^+\pi^+\pi^-\pi^-$ selected from the channel $\bar{p}p \to 3\pi^+ 3\pi^-\pi^0$ at 715 MeV/c: one in $\omega^0\pi^{\pm}$ at 1040 MeV ($\Gamma \approx 55$ MeV) and two in $\omega^0\pi^+\pi^-$, respectively near 1315 MeV ($\Gamma \approx 100$ MeV) and 1405 MeV ($\Gamma \approx 40$ MeV). The first two effects are strongly correlated and are interpreted in terms of a sequential decay of $A_2^0$ through a new object, the $B_1$. The second ($\omega\pi\pi$) enhancement seems to be an $\omega^0\rho^0$ effect below threshold and is attributed to a pionic decay of the $(K\bar{K})_{I=1}$ effect seen around the same mass in other reactions. (auth)

**23344** SEARCH FOR $\rho'$ PRODUCTION IN $\pi^+p$ INTERACTIONS AT 5 GeV/c. Eisenberg, Y.; Karshon, U.; Mikenberg, J.; Pitluck, S.; Ronat, E. E.; Shapira, A.; Yekutieli, G. (Weizmann Inst. of Science, Rehovot, Israel). Phys. Lett. B; 43B: No. 2, 149-152(22 Jan 1973).

An upper limit of 0.006 is obtained for the ratio $\pi^+p \to \Delta^{++}\rho' / \Delta^{++}\rho^0$, with $\rho' \to \rho^0\pi^+\pi^-$. Assuming OPE this leads to $g^2_{\rho'\pi\pi} / g^2_{\rho\pi\pi} < 0.02$. Other decay modes of the $\rho'$ are also discussed. (auth)

**23345** POSSIBLE NEW RESONANT STATE BELOW THE Λ(1520) STATE. Cline, D.; Laumann, R.; Mapp, J. (Univ. of Wisconsin, Madison). Lett. Nuovo Cim.; 6: No. 6, 205-210 (10 Feb 1973).

Evidence for a possible new resonant state is obtained from data from a deuterium-filled bubble-chamber exposure to a septum-separated $K^-$ beam at 340 and 400 MeV/c. The following reactions were studied: $K^-d \to \Lambda\pi^-p$, $K^-d \to \Sigma^0\pi^-p$, $K^-d \to \Sigma^-\pi^+n$, and $K^-d \to \Sigma^+\pi^-n$. A partial-wave analysis favors a rapid variation of the $D_3$ amplitude and suggests a resonant structure. It is suggested that if the resonant activity observed is confirmed as a new resonant state, the state is likely to be a MacDowell partner of the Σ(1385) state. (LBS)

**23346** INVESTIGATIONS OF RESONANCE PRODUCTION IN THE REACTION $\pi + p \to \pi + \pi + n$ IN THE PRIMARY $\pi^+$-MESON MOMENTUM INTERVAL 1.6 TO 4 GeV/c. Kanazirskii, Ch. God. Vissh. Tekh. Ucheb. Zaved., Fiz., 6: No. 2, 13-34(1969). (In Bulgarian).

The experimental data are presented concerning the investigation of resonance production in the reaction $\pi + p \to \pi + \pi + n$ in the primary $\pi^+$ meson momentum interval 1.6 to 4 GeV/c. Our experimental results at the primary $\pi^+$-meson momentum of 2.54 GeV/c are compared with the results of other authors. (Abstr. Bulg. Sci. Lit. Math., Phys. Astron., Geophys., Geod.)

## Particle Interactions and Properties (Theoretical)

### *General*

*Refer also to abstracts 23153, 23413, and 23422.*

**23347** (AD-748944) ANALYSIS OF PARTICLE DYNAMICS AND SUBNUCLEAR SYSTEMS BASED ON REGGE POLE CALCULATIONS, AND CURRENT ALGEBRAS AND THE QUARK MODELS. Final Report. Ahmadzadeh, A. (Arizona State Univ., Tempe. Dept. of Physics). 24 Jun 1972. 21p. NTIS.

The topics of research were the phenomenology of high energy physics and dynamics of strong interaction involving Regge poles, cuts and higher symmetries. Specific accomplishments included the detailed classification of known isotriplet and isodoublet mesons into exchange degenerate octets of Regge trajectories, which accommodates all the established mesons and is in agreement with the quark model; development of a formalism pseudoscalar and axial vector octets which successfully resolved numerous difficulties in polarization and cross-over phenomena; and the development of a model which explains the photoproduction of $\pi^+$ mesons at high energies and small scattering angles. (auth)

**23348** (HU-P-36) EVALUATION OF PHASE SPACE INTEGRALS BY STATISTICAL METHODS AND APPLICATIONS WITH CUT IN TRANSVERSE MOMENTUM. Karimaeki, V. (Helsinki Univ (Finland). Dept. of Nuclear Physics). 10 Dec 1971. 87p. INIS.

A special method for the evaluation of the momentum phase space integrals is described. The method, based on the formation of statistical mechanics, has the restriction that the weight function $F(p_1, \ldots, p_n)$ must factorize in particle momenta. The case that weight function F only depends on the transverse momenta of the particles and factorizes is studied. F is chosen such that it gives the so-called transverse momentum cut-off. The corresponding numerical program is listed. Some physical consequences of the transverse momentum cut, especially total cross sections, average multiplicity, and single particle distributions are discussed in some detail. (LMK) (Finland)

**23349** (IFVE-STF-72-54) INCLUSIVE PROCESSES AT HIGH ENERGIES. Ezhela, V. V.; Logunov, A. A.; Mestvirishvily, M. A.; Petrov, V. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1972. 53p. (In Russian). Dep. NTIS (U. S. Sales Only). $4.75.

New physical characteristics for inclusive processes are discussed, i.e., mean multiplicity in different subdomains of phase volume. The analyses of pionization hypothesis, scale invariance, and limiting fragmentation from the viewpoint of analyticity and unitarity is given. The upper bound on cross section $d^2\sigma ab \rightarrow cd/d \cos \theta dy$ is improved. It is shown that with our assumptions on analyticity the obtained bound can not be improved in the sense of power dependence or energy. (auth)

**23350** (INP-806, pp 20-45) DIFFRACTIVE DISSOCIATION IN INCLUSIVE REACTIONS. Chan, H. M. (Rutherford High Energy Lab., Chilton, Eng.). 1972.

General features of diffractive dissociation in inclusive reactions are discussed especially in the case when it dominates the high energy total cross section. (auth)

**23351** NULL DIVERGENCE TENSORS IN THE THEORY OF PARTICLES HAVING ZERO OR UNIT SPIN. Durand, Emile (Univ., Toulouse). Compt. Rend., Ser. B; 275: No. 18, 641-643(30 Oct 1972). (In French).

The wave equation describing the behavior of particles with spin 0 and spin 1 in the absence of a field is presented. The 5th order irreducible representation of the $\beta$ matrices corresponds to particles with spin 0, while the 10th order irreducible representation corresponds to particles with spin 1. Conjugate tensor equations are introduced. It is verified that the $T_{A,r}$ tensors have a null divergence on the r index. The $T_{0,r}$ and $T_{p,r}$ tensors corresponding to the current-charge density and to the energy-momentum density were re-established together with certain new tensors. (auth)

**23352** NOTE ON ELECTRON STABILITY AND THE PAULI PRINCIPLE. Reines, F.; Sobel, H. W. (Univ. of California, Irvine). pp 135 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfruered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

A very short note is given on the possible connection between electron stability and the Pauli principle. (WDM)

**23353** PROGRAMS FOR COMPUTING THE LOGARITHM OF THE GAMMA FUNCTION, AND THE DIGAMMA FUNCTION, FOR COMPLEX ARGUMENT. Koelbig, K. S. (CERN, Geneva). Comput. Phys., Commun.; 4: No. 2, 221-226(Nov 1972).

The programs CLOGAM and CDIGAM written in FORTRAN IV for the CDC 6600 computer are described for computing the logarithm of the gamma function and the digamma function for the Veneziano model and the Coulomb phase shift for complex energies. (JFP)

## *Electromagnetic*

*Refer also to abstracts 23418 and 23850.*

**23354** (INR-1385/7/PH) FAMILY OF SUM RULES FOR WEAK ELECTROMAGNETIC AND STRONG PROCESSES. Lukaszuk, L. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 34p. INIS.

New sum rules are derived for the neutrino-electron, pion-pion, Compton forward scattering amplitudes and for the pion's electromagnetic form factor. It is also shown that a peak in the differential cross section or form factor has to be connected with the positive derivative of phase at the maximum, provided that the peak is steep enough and/or dominating over a sufficiently large region. (auth)

**23355** (LNF-72/93) EXPERIMENTAL LIMITS ON THE VALUE OF THE ANOMALOUS DIMENSIONS. Parisi, G. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratori Nazionali di Frascati). 27 Oct 1972. 4p. Dep. NTIS (U. S. Sales Only) $3.00.

We show how to use the data on deep inelastic e-p scattering to put bounds on the values of the anomalous dimensions of the operators involved in the Wilson expansion of the product of two currents near the light-cone. Anomalous dimensions of the order of unity are found not to be in contrast with present experimental evidence. (auth)

**23356** (RLO-2041-77) PREDICTIONS FOR PION-NUCLEON BREMSSTRAHLUNG. Vignola, F. E. 1972. 5p. (CONF-720819-19). Dep. NTIS $3.00.

From International conference on few particle problems in nuclear interactions; Los Angeles, California, USA (28 Aug 1972).

The total model independent part of the pion-nucleon bremsstrahlung differential cross section is calculated to show its use in the estimation of the magnitude of the off-energy-shell effects. Some preliminary results are presented which demonstrate the application of the calculation. (auth)

**23357** MAGNETIC MOMENTS OF THE DUAL PION MODEL. Matsuda, S.; Saito, T. (International Centre for Theoretical Physics, Trieste, Italy). Phys. Lett. B; 43B: No. 2, 123-126 (22 Jan 1973).

The electromagnetic problems of the dual pion model proposed by Neveu and Schwarz are considered. The photon gauge substitution and the supergauge algebra appearing in this model are shown to determine the interaction uniquely. As a consequence a general formula of the magnetic moments is given and the universal value $g = 2$ of the g factor for all the states is found. (auth)

**23358** EXPERIMENTAL TEST OF THE LOW-ENERGY THEOREM FOR $\gamma \rightarrow 3\pi$. Chanda, R. (University Coll., Dublin). Lett. Nuovo Cim.; 6: No. 7, 270-272(17 Feb 1973).

It is suggested that the soft-pion relation between the $\gamma \rightarrow 3\pi$ and the $\pi^0 \rightarrow 2\gamma$ amplitudes can be experimentally verified from a study of the process $e^+ + e^- \rightarrow$ "$\gamma$" $\rightarrow \pi^+ + \pi^- + \pi^0$. The total cross section for this process is computed as a function of the timelike photon mass. A numerical calculation shows that the low-energy theorem under study is at least consistent with experimental results. (LBS)

**23359** PROBLEMS IN ELECTROMAGNETIC MASS-DIFFERENCE CALCULATIONS. Majumdar, D. P. (Univ. of Michigan, Ann Arbor). Curr. Sci. (India); 42: No. 5, 151-155(5 Mar 1973).

A brief review is given on the progress made in calculating the electromagnetic mass differences of elementary particles. In particular, the problems encountered in the various methods are discussed. (LBS)

**23360** SECOND-ORDER NON-ABELIAN COMPTON EFFECT AND GENERALIZED MAGNETIC-MOMENT RADIUS THEOREM. Ragusa, S. (Instituto de Fisica e Quimica, Sao Carlos, Brazil). Lett. Nuovo Cim.; 6: No. 6, 215-218(10 Feb 1973).

The non-Abelian Compton effect on nucleons was previously studied to second order in the frequency of the incident photon and two low-energy theorems were derived, one of which is related to the isotopic-spin antisymmetric part of the amplitude and involves the magnetic-moment charge radius. These second-order theorems are extended for $J = 3/2$ targets. A generalized form for the magnetic-moment radius theorem is obtained. The theorem is written in a form shown to be valid for lower spins and conjectured to be valid for higher spins. In addition two new theorems related to the isovector magnetic-octupole moment of the system are presented. (LBS)

**23361** VACUUM STATE OF A RELATIVISTIC SYSTEM INTERACTING WITH AN EXTERNAL FIELD. Oleinik, V. P. (Inst. of Semiconductors, Kiev). Ukr. Fiz. Zh. (Russ. Ed.); 18: No. 1, 105-117(Jan 1973). (In Russian).

The exact solution of the problem of interaction between an electron-positron system with time-dependent electrical field is obtained and investigated. It is shown that the vacuum state of such a system is unstable with respect to the creation of electron-positron pairs in the electrical field. The instability of the vacuum is very considerable and is manifested in orthogonality of the state vectors of the bare and physical vacua: $\langle 0|S|0\rangle = 0$ ($|0\rangle$ is a state vector of the bare vacuum; S—a scattering operator). A renormalization procedure is proposed for removing infinites in the average values of the physical quantities. According to this procedure, the average value of any physical magnitude in the vacuum state is taken for an origin of reading of this magnitude. (auth)

**23362** ELECTRON IN THE FIELD OF THE QUANTIZED ELECTROMAGNETIC PLANE WAVE. Bagrov, V. G.; Bozrikov, P. V.; Gitman, D. M. (Tomsk Polytechnical Inst.). Teor. Mat. Fiz.; 14: No. 2, 202-210(Feb 1973). (In Russian).

The wave functions are found for a system including a charge and quantized electromagnetic field of a plane wave. The plane wave is represented by its expansion over the photons with definite momentum and polarization values. The interaction between the electron and all the photons in the wave is taken into account exactly. The problem is solved by means of the method of canonical transformations of the creation-annihilation operators, the explicit form of the latter being not given. Properties of the solutions obtained are studied, and their connection with the Volkov solutions is pointed out. (auth)

**23363** SOLUTION OF THE EQUATIONS OF MOTION OF A CHARGED PARTICLE IN A STATIONARY MAGNETIC FIELD. Metcalf, M.; Regler, M. (CERN, Geneva). J. Comput. Phys.; 11: No. 2, 240-249(Feb 1973).

It is often necessary in high energy physics experiments to be able to make fast calculations of the paths of charged particles in a magnetic field, for both Monte Carlo and reconstruction programs. If it is possible to represent the field analytically in a Cartesian coordinate system by nonnegative powers of $x_1$, $x_2$, $x_3$, then the differential equation of motion may be solved by comparison of coefficients. (auth)

**23364** FERMI PARTICLE EMISSION IN THE FIELD OF TWO ELECTROMAGNETIC WAVES. Klimenko, Yu. I.; Khudomyasov, A. I. (Tomsk Polytechnic Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 11, 55-60(1972). (In Russian).

An electron which possesses an anomalous magnetic moment in the field of two plane electromagnetic waves is considered. The waves are assumed to have different frequencies but the same direction of propagation. Formulas were obtained for the power of photon emitted by the electron in the field of these waves. The possibility of radiating a photon from a neutral Fermi particle in such a field is discussed. (tr-auth)

**23365** EFFECT OF RADIATION FRICTION ON CHARGE MOVEMENT IN A UNIFORM MAGNETIC FIELD AND THE FIELD OF A PLANE ELECTROMAGNETIC WAVE. Khalilov, V. R.; Kholomai, B. V. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; 13: No. 5, 558-565(1972). (In Russian).

Electron movement through a constant uniform magnetic field and a field of a plane, electromagnetic wave was examined using the methods of classical theory. A solution to the equations developed was obtained for such a field without attenuation, the solution satisfying the initial conditions. Calculation of the radiation friction leads to an effective increase in the energy of the electron over a considerable interval of time. (tr-auth)

## Weak

*Refer also to abstracts 23326, 23328, and 23330.*

**23366** (JINR-E1-6907) REAL TIME ON-LINE PROGRAMS FOR THE π-e SCATTERING EXPERIMENT USING AN HP 2116B COMPUTER. I. Adylov, G. T.; Aliev, F. K.; Gaevski, V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1973. 16p. Dep. NTIS (U. S. Sales Only) $3.00.

On-line programs for the π−e scattering experiment using an HP 2116B computer are described. The software controls the transfer of data into the computer and out onto the magnetic tape. The experimenter can control and experiment through a panel of push buttons and switch registers. The computer output allows one to check an experimental setup and run characteristics. (auth)

**23367** (JINR-E1-6908) REAL-TIME ON-LINE PROGRAMS FOR THE π-e SCATTERING EXPERIMENT USING AN HP 2116B COMPUTER. II. Adylov, G. T.; Aliev, F. K.; Gaevski, V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1973. 18p. Dep. NTIS (U. S. Sales Only) $3.00.

The trackfinding programs are described which recover "pair" events by geometric and kinematic criteria at the real-time of the π−e experiment using an HP 2116B computer. (auth)

**23368** (JINR-E1-6909) REAL-TIME ON-LINE PROGRAMS FOR THE π-p ELASTIC SCATTERING EXPERIMENT USING AN HP 2116B COMPUTER. Adylov, G. T.; Aliev, F. K.; Gaveski, V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1973. 10p. Dep. NTIS (U. S. Sales Only) $3.00.

On-line programs are described which control an experimental setup and analyze events by geometrical and kinematic criteria at the real time of the π−p elastic scattering experiment using an HP 2116B computer. (auth)

**23369** WEAK INTERACTIONS. Deshpande, N. G. (Northwestern Univ., Evanston, IL). Curr. Sci. (India); 42: No. 5, 155-157(5 Mar 1973).

Some of the unsolved problems in weak interaction are briefly discussed; a more detailed review is given of a particular one, namely, a finite theory of weak interactions. (LBS)

**23370** PHENOMENOLOGICAL THEORY OF DEPOLARIZATION OF $\mu^+$-MESONS IN MAGNETIC MEDIA. Ivanter, I. G. (Inst. of Atomic Energy, Moscow). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1873-1882(Nov 1972). (In Russian).

An equation set for depolarization of $\mu^+$-mesons in magnetic semiconductors is formulated. It is shown that the presence of polarization of conductivity electrons results in the appearance of $\mu^+$-polarization along the direction of polarization of the medium electrons and also leads to an additional shift of the muon precession frequency in a magnetic field about the direction of the conductivity electron polarization and to a displacement of the precession stopping point. Polarization of captured electrons leads, in particular to a significant phase shift of the complex residual polarization. It is thus shown that $\mu^+$-mesons may effectively be used for studying magnetic semiconductors. The results also show that the state of $\mu^+$-mesons in ferromagnetic metals (atomic or ionized) can be determined. (auth)

**23371** SECOND CLASS CURRENTS IN WEAK INTERACTIONS. Pietschmann, H. (Univ., Vienna). pp 239-246 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

The discussion of second-class currents in weak interactions covers the induced mesonic and pseudotensor second-class currents, hypercharge changing transitions, and a decuplet second-class current. (JFP)

**23372** THEORETICAL APPROACHES TO $Kl_3$. Paver, N. (Univ., Trieste, Italy). pp 269-280 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

A brief review of three-body leptonic kaon decay is given from the viewpoint of current algebra, light-cone algebra, and related techniques. (JFP)

**23373** DECAY $K_L \rightarrow 2\mu$ (REVIEW). Dolgov, A. D.; Okun, L. B.; Zakharov, V. I. (Inst. for Theoretical and Experimental Physics, Moscow). pp 281-321 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

The review of $K_2^0 \rightarrow 2\mu$ covers the reliability of theory and experiment, conservative theory of the studied decay, possible new interactions and particles, and new violations of principles. (JFP)

**23374** REVIEW OF THE $K_L^0 \rightarrow \mu^+ + \mu^-$ PUZZLE. Oakes, R. J. (Northwestern Univ., Evanston, IL). pp 323-335 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

In this review of the $K_2^0 \rightarrow \mu^+ + \mu^-$ puzzle the results from the examination of the validity of the theoretical assumptions are discussed. (JFP)

### *Strong (General)*

**23375** (COO-3285-1) COVARIANT PARTON DYNAMICS. Domokos, G.; Koevesi-Domokos, S. (Johns Hopkins Univ., Baltimore, Md. Dept. of Physics). Jan 1972. Contract AT(11-1)-3285. 44p. Dep. NTIS.

We propose a dynamical theory of hadrons in terms of partons. Partons are defined as free particle-like states in a reference frame moving with the velocity of light. Lorentz covariance properties of the theory are investigated; we give a method of constructing a class of covariant interactions directly in terms of parton operators. A transverse harmonic oscillator potential between parton pairs is suggested as an effective interaction giving rise to the observed meson spectrum. The parton-system exhibits collective excitations; in a Hartree-Fock approximation the latter correspond to free mesons. The elastic scattering amplitude of spinless mesons is calculated in an external field approximation. At moderate energies the amplitude exhibits local duality. (auth)

**23376** (COO-3285-4) RESEARCH IN THEORETICAL PHYSICS. Annual Progress Report, April 1, 1972—March 31, 1973. Domokos, G. (Johns Hopkins Univ., Baltimore, Md.). Dec 1972. Contract AT(11-1)-3285. 23p. Dep. NTIS.

Phenomenological parton models and the short distance behavior of hadronic scattering amplitudes were investigated. The kinematical structure of parton models (null plane dynamics) was clarified. Phenomenological interactions were investigated in the Hartree-Fock approximation. The system under consideration exhibits many-body properties including collective excitations. A model amplitude was constructed by summing over collective models in intermediate states. The amplitude exhibits approximate Regge behavior at high energy and fixed momentum transfer. The short distance behavior of amplitudes was investigated under the following main assumptions: hadrons are "composite" objects; the theory is conformally invariant at short distances. The description of composite objects in a conformally invariant framework was clarified. Explicit integral representations of n-point scattering amplitudes were constructed in the conformal limit and their momentum-space properties were analyzed, independently of specific models. It is found in particular that amplitudes in the conformal limit exhibit weak duality. Investigation of a simple model shows that physically reasonable scaling laws are obtained for amplitudes at large momentum transfers. This annual report also summarises briefly the main results of earlier investigations. (auth)

**23377** (INP-806) DIFFRACTIVE PRODUCTION PROCESSES AT HIGH ENERGIES. Proceedings of the XII Cracow School of Theoretical Physics, Zakopane, June 8—18, 1972. (Institute of Nuclear Physics, Krakow (Poland)). Jun 1972. 305p. Dep. NTIS (U. S. Sales Only).

The conference included 10 papers one of which was abstracted previously in NSA as 26: 57337. Separate abstracts were prepared for nine papers. (JFP)

*For abstracts of individual papers see: 23340, 23350, 23378, 23390—23392, 23396, 23397, and 23611.*

**23378** (INP-806, pp 227-298) PRESENT EXPERIMENTAL STATUS OF HELICITY CONSERVATION IN DIFFRACTIVE PROCESSES. Otter, G. (Institut fuer Hochenergiephysik, Vienna). 1972.

The review lectures on helicity conservation in diffractive processes cover the helicity formalism and helicity conservation for the two-body reactions and for the general case. (JFP)

**23379** DIFFRACTIVE MODELS AND HIGH MULTIPLICITIES. Le Bellac, M.; Meunier, J. L. (Univ., Nice). Phys. Lett. B; 43B: No. 2, 127-131(22 Jan 1973).

It is shown that diffractive models in their present form cannot fit simultaneously the multiplicity distribution at high energy and the inclusive one-particle cross section in the central region. (auth)

**23380** QUANTITATIVE MEASURE OF CLUSTER FORMATION IN MULTIPARTICLE PRODUCTION. Berger, E. L. (CERN, Geneva); Fox, G. C.; Krzywicki, A. Phys. Lett.; 43B: No. 2, 132-136(22 Jan 1973).

A dispersion parameter for individual events is defined and advocated as a quantitative measure of clustering of particles along the longitudinal rapidity axis in high energy multiparticle interactions. General arguments and Monte Carlo simulations indicate that the parameter should discriminate between fragmentation-type and multiperipheral-type models at $p_{lab} \gtrsim 100$ GeV/c. (auth)

**23381** INTEGRAL EQUATIONS FOR HADRONIC CORRELATION FUNCTIONS. Manesis, E. K. (Univ. of Chicago). Phys. Lett.; 43B: No. 2, 137-140(22 Jan 1973).

A reasonable extension of the Feynman hadron-liquid analogy at the microscopic level is offered, based on a class of models for hadron production, and integral equations between inclusive and exclusive correlation functions are derived. The simplest of them is solved to predict the two-pion exclusive correlation, given the recent ISR inclusive data, and it is successfully applied to problems where duality and isospin play an important role. (auth)

**23382** ELIMINATION OF SPURIOUS LOW-ENERGY EFFECTS OCCURRING IN THE MODEL OF PLAHTE AND ROBERTS. Schlesinger, J. (State Univ., Mons, Belgium). Lett. Nuovo Cim.; 6: No. 7, 241-244(17 Feb 1973).

A correction factor is introduced into the phenomenological model of Plahte and Roberts for multiparticle production in order to eliminate the unwanted feature of simultaneous poles in adjacent subamplitudes. The corrected version of the model is tested on the reaction $K^+p \rightarrow K^0\pi^+p$ at 3.5 GeV/c, and is shown to constitute an improvement in the c.m.s. angular distribution of $\pi^+$. (LBS)

**23383** UNSOLVED PROBLEMS IN QUARK MODEL AND HADRON SPECTRA. Mitra, A. N. (Indian Inst. of Science, Bangalore, India). Curr. Sci. (India); 42: No. 5, 159-161(5 Mar 1973).

A panoramic view of the major developments in the field of resonance physics is given, followed by a discussion of some of the unsolved problems in the quark model and the hadron spectra. (LBS)

**23384** SEMI-LOCAL DUALITY AND FESR PROBLEMS FOR VENEZIANO MODELS. De Achterberg, M. C. (Univ., Buenos Aires); Della Selva, A.; Masperi, L.; Page, R. Lett. Nuovo Cim.; 6: No. 6, 211-214(10 Feb 1973).

A study is made of the semi-local duality properties of Veneziano amplitudes applied to total and one-particle inclusive cross sections, as analyzed by De Tar et al. (Phys. Rev. D, 4: 425(1971)), in order to clarify the discrepancies appearing in the FESR. In order to test the semi-local duality, the average of the imaginary part of the amplitude over one resonance is performed and its asymptotic behavior is compared with the Regge-pole expansion evaluated at the resonance position. (LBS)

**23385** QUANTUM FIELD FORMALISM OF THE NUCLEON—$K_\alpha$ BOSON MODEL FOR HADRONS. Kushnirenko, A. N. (Inst. of Problems in Materials Studies, Kiev). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 11, 48-54(1972). (In Russian).

The author had previously (1971) proposed a model for hadrons based on a hypothetical pseudovector isospin boson existing in nature, its mass exceeding the nucleon mass by a factor of three, its lifetime being very short. Here he is concerned with a quantum field formalism of this model, and further makes an attempt to include leptons in the general scheme. (KSW)

**23386** PHYSICAL LADDERS AND RELATIVISTIC GENERALIZATIONS. Nikolov, A. V. (Univ., Sofia). Compt. Rend. Acad. Bulg. Sci.; 25: No. 12, 1613-1616(1972). (In Russian).

Physical ladders had previously been introduced by S. Drenska et al. (1972) in order to construct a unified scheme of hadron classification. A relativistic generalization is given with the help of U(6,6).T(143) groups, confined to the terminology and symbolism of A. Nikolov (1972). It was shown possible to transpose the classification of hadrons from a system at rest into another system. (KSW)

**23387** DURHAM ELEMENTARY PARTICLE DATA BANK, DATA ANALYSIS, AND MODEL COMPARISON PROJECT. Gault, F. D.; Chadwick, B.; Cooper, C. S.; Bransden, B. H. (Univ. of Durham, Eng.). Comput. Phys. Commun.; 5: No. 2, 98-103(Feb 1973).

In comparing theoretical models with data the first problem encountered is the retrieval of data from published sources and its storage in such a way as to make it readily accessible. The second is to implement programs which check the data for consistency and any recurring characteristics. The third is to produce an efficiently written programme to compare the theoretical model with the data, the programme being written as a function of N parameters so that it can be coupled to a minimizing programme such as CERN MINUIT. Between each step, interface, retrieval and storage problems arise. We discuss the organization of the Durham project, the Data Bank software and retrieval techniques, and the integration of model independent software with the Data Bank. This project is being carried out on the Northumbrian Universities Multiple Access Computer (NUMAC), an IBM 360/67 operating under the Michigan Terminal System (MTS). (auth)

**23388** COMPUTATION OF EFFECTIVE REGGE TRAJECTORIES FOR HIGH ENERGY TWO-BODY REACTIONS. Harrison, D. J.; Irving, A. C.; Martin, A. D. (Univ. of Durham, Eng.). Comput. Phys. Commun.; 5: No. 2, 153-160(Feb 1973).

The program EFFECTIVE REGGE TRAJECTORIES written in FORTRAN IV for the IBM 360/67 is described for calculating the effective Regge trajectory from the differential cross sections for strong interactions. The option is included of determining the t-dependence overall normalization of a given experiment, and the slope of the differential cross section and the integrated cross sections are calculated. (JFP)

**23389** SIXTEENTH INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS. 3. Quark Charges. Callan, C. G. (Princeton Univ., NJ). Comments Nucl. Particle Phys.; 5: No. 4, 125-128(Jul 1972).

Comments are offered on work reported relating to quark charges at the Sixteenth International Conference on High Energy Physics, University of Chicago, September 1972. A recurring theme was the possible existence of various exotic particles needed in new schemes for weak and electromagnetic processes. Interest was focused largely on the particle "zoo" postulated by the builders of gauge theories of weak interactions. At present this particle contains only empty cages, none of the needed vector mesons or heavy leptons having been found. A similar problem faces the parton model and light cone enthusiasts in that the simplest choice for partons or current constituents is quarks of the classic non-integral charge variety, and no such particles have yet been found. New data, bearing directly on these problems, were presented at the conference, and a summary is given as to what can now be said about quarks as current constituents. Particular attention is given to CERN measurements. (UK)

### *Strong (Baryon No. = 0)*

**23390** (INP-806, pp 4-19) RELATIVISTIC QUARK MODEL FOR DIFFRACTIVE EXCITATION OF MESONS. Byers, N. (Univ. of California, Los Angeles). 1972.

A fully relativistic model of diffractive excitation of mesons is presented in which the meson–baryon and meson–meson amplitudes are approximated as a multiple scattering expansion in quark–quark elastic scattering amplitudes similar to the Glauber multiple scattering expansion. The form of the amplitudes and cross sections are found for $\pi^+\pi^-$ elastic scattering at high energy and small momentum transfer. (JFP)

### *Strong (Baryon No. = 1)*

**23391** (INP-806, pp 180-216) ISOSPIN ANALYSIS OF HADRONIC DIFFRACTIVE PRODUCTION. Koba, Z. (Niels Bohr Inst., Copenhagen). 1972.

Two important aspects of the isospin analysis of hadronic diffractive production processes are discussed. They are cross channel isospin representation, and isospin analysis of "integrated cross sections." Examples are taken from single pion production in $\pi$N and NN collisions, and graphical illustration of the results are presented. (auth)

**23392** (INP-806, pp 217-226) PARTIAL WAVE ANALYSIS OF DIFFRACTIVELY PRODUCED SYSTEMS. Kotanski, A. (Jagellonian Univ., Krakow). 1972.

The ascoli method for the partial wave analysis of the $3\pi$ system produced diffractively is discussed. The tests of the factorization assumption are proposed. It seems that the most efficient test is to compare the density matrix elements for events in various regions of the Dalitz plot. (auth)

**23393** APPLICATION OF DISPERSION SUM RULES FOR $\pi^-p$ CHARGE EXCHANGE REACTION IN THE DOUBLE REGGE POLES MODEL. Krzyzanowski, W. (Univ., Warsaw). Bull. Acad. Pol. Sci., Ser. Sci., Math., Astron. Phys.; 20: No. 10, 891-894(1972).

Dispersion sum rules (FESR and CMSR) constitute rather a delicate instrument for investigation of scattering amplitudes, which have Regge-like behavior in the high energy region. Continuous moment sum rules are analyzed in the case of $\pi^-p$ charge exchange reaction. This process has been described by exchange of $p^-$ meson trajectory, treated here like a double one. (auth)

**23394** LEADING PARTICLES AND CHARGED PARTICLE MULTIPLICITY IN ANNIHILATION AND NON-ANNIHILATION INTERACTIONS. Athens-Democritos-Liverpool-Vienna Collaboration Phys. Lett.; 43B: No. 2, 146-148(22 Jan 1973).

Using data from the $K^-p$ experiment at 8.25 GeV/c the charged particle multiplicity, and the variation of charged pion multiplicity as a function of the effective mass squared of all pions were measured for various samples of data, and the results with $\bar{p}p$ annihilation data and pp data. Evidence is presented which suggests that the difference in behavior between the annihilation and non-annihilation data is not due to some specific mechanism such as baryon exchange, but is related to the absence of leading particles in the former case. (auth)

**23395** PION EXCHANGE AND INCLUSIVE REACTIONS $\pi^-p \rightarrow \rho^0X$ AND $K^+p \rightarrow pK^{*+}(890)X$. Ishikawa, K.; Kasahara, T.; Miyake, S. (Tohoku Univ., Sendai). Lett. Nuovo Cim.; 6: No. 7, 263-266(17 Feb 1973).

The triple-Regge formula with well-defined normalization factors is applied to the processes $\pi^-p \rightarrow \rho^0X$ and $K^+p \rightarrow K^{*+}X$ in order to examine the pion pole effect in the fragmentation region. It is found that the theoretical result is in good agreement with data in the meson fragmentation region of $\pi^-p \rightarrow \rho^0X$; in the case of $K^+p \rightarrow K^{*+}X$ a large discrepancy exists. It is conjectured that the meson fragmentation process of $\pi^-p \rightarrow \rho^0X$ is dominated by the one-pion exchange and the $K^+p \rightarrow K^{*+}X$ by the exchange of normal-parity trajectories, $\omega$, $\rho$, etc., rather than of the pion pole. (LBS)

### *Strong (Baryon No. ≥ 2)*

**23396** (INP-806, pp 46-82) MODELS OF DIFFRACTIVE PRODUCTION PROCESSES ON SIMPLE AND COMPOSITE TARGETS. Czyz, W. (Inst. of Nuclear Physics, Krakow). 1972.

A unified description of diffractive production processes on nucleons and nuclei based on model proposed some time ago by A. Bialas, A. Kotański and the author is discussed. (auth)

**23397** (INP-806, pp 83-86) RELATIVISTIC SYSTEMS AND THE GLAUBER THEORY OF HIGH ENERGY SCATTERING IN THE QUARK MODEL. Summary of Lectures. Dalitz, R. H. (Oxford Univ.). 1972.

The Glauber multiple scattering formalism is reviewed for two colliding systems each made up of subunits. Proton–proton interactions are discussed. (JFP)

**23398** (LA-5171-MS) n–d BREAKUP REACTION AND THE n–n SCATTERING LENGTH. Gibson, B. F.; Stephenson, G. J. Jr. (Los Alamos Scientific Lab., N. Mex.). Feb 1973. Contract W-7405-eng-36. 7p. Dep. NTIS. $3.00.

A simple approximation to the Faddeev theory of the n–d breakup reaction is reviewed in an attempt to emphasize the difficulty of obtaining a precision measurement of the n–n scattering length using this reaction mechanism. (auth)

**23399** (RLO-2041-75) PION AND PROTON INCLUSIVE DISTRIBUTIONS IN THE DIFFRACTIVE EXCITATION MODEL. Holden, J. P.; Robertson, D. C. (Oregon Univ., Eugene. Inst. of Theoretical Science). 1972. Contract AT(45-1)-2230. 31p. Dep. NTIS $3.75.

The leading one-particle distributions for the inclusive reaction $pp \rightarrow cX$ ($c = p, \pi^+$) calculated in the diffractive excitation model (DEM) are compared to the new ISR data. For the pion distribution we show that a single Gaussian decay distribution, $[\exp(-\lambda k^2)]$, even with the added assumptions of momentum conservation and off-axis scattering of the clusters, is unable to fit the data. We then show that a pion decay distribution given by a sum of two Gaussians does fit both the fixed-x and fixed-$p^2$ distributions. The proton distributions are well fit by a single Gaussian decay distribution. The proton spectrum exhibits a broad dip at $x \sim .85$ which is naturally explained in the DEM as protons emanating from a cluster ($x \lesssim .8$) and unexcited protons recoiling against a massive cluster ($x \gtrsim .9$). (auth)

**23400** POLARIZATION EFFECTS IN HIGH-ENERGY LARGE-ANGLE p-d SCATTERING. Ots, I. (Inst. of Physics and Astronomy, Tallin, USSR). Izv. Akad. Nauk Est. SSR, Fiz. Mat.; 21: No. 4, 455-456(1972).

It is suggested that the hypothesis of resonance exchange models can be tested by investigation of the polarization effects in high energy, large-angle scattering, due to the fact that the pole diagram model with nucleon transfer and those with resonance exchange have different polarization effects. The Kerman–Kisslinger model for pd scattering in the GeV range is briefly discussed. (LBS)

**23401** PERIPHERAL COMPONENT OF N–N SCATTERING AMPLITUDES AT LOW ENERGIES. Kawasaki, M. (Hiroshima Univ.); Susuki, Y.; Matsuda, M.; Suemitsu, H. Lett. Nuovo Cim.; 6: No. 6, 227-231(10 Feb 1973).

It is demonstrated that the imaginary parts of the impact-parameter amplitudes of N–N scattering have peripheral components at low energies. (LBS)

**23402** SHADOW CORRECTIONS TO THE PION–DEUTERON AND PROTON–DEUTERON COLLISIONS. Anisovich, V. V.; Volkovitskii, P. E.; Dakhno, L. G. (Inst. of High Energy Physics, Serpukhov, USSR). Zh. Eksp. Teor. Fiz., 63: No. 5, 1576-1585 (Nov 1972). (In Russian).

High energy shadow corrections are expressed in terms of the inclusive process cross sections. It is shown that shadow corrections determined with a high degree of accuracy yield additional information regarding the mechanism of inelastic processes. A comparison of the calculated corrections and experimental values shows that antishadow effects play a large role in rescattering for large masses in the intermediate state. (auth)

**23403** DETERMINATION OF NEUTRON–NEUTRON SCATTERING LENGTH FROM $\pi^-d \rightarrow 2n + \gamma$ REACTION. Shklyarevskii, G. M. (Inst. of Nuclear Physics, Leningrad). Yadern. Fiz.; 16: No. 6, 1270-1278(1972). (In Russian).

With the help of nonrelativistic graphical technique there is studied the spectrum of neutron relative energies in the reaction of radiative capture $\pi^-d \rightarrow 2n + \gamma$. The corrections related to rescattering of pion and nucleons in intermediate states were calculated. It was shown that processing of experimental data with application of formulas obtained should bring one to the scattering length of neutron on neutron equal to $\simeq -(17 \text{ to } 18)$ F. (auth)

**23404** ISOSPIN CONSTRAINTS FOR TWO-PARTICLE DISTRIBUTIONS IN PROTON–PROTON INTERACTIONS. Muetter, K. H.; Rothe, H. J. (Univ., Heidelberg). Z. Phys.; 257: No. 5, 369-379(1972).

Inequalities which relate the $(2I_A + 1)(2I_B + 1)$ two-particle spectra in the reaction $p + p \rightarrow A + B$ + anything are derived from isospin invariance, where the measured particles in the final state belong to isospin multiplets $I_A, I_B = 0, \frac{1}{2}, 1$. (2 figures, 1 table) (auth)

**23405** ENERGY OF BOSONS EMITTED DURING A NUCLEUS-FAST PARTICLE INTERACTION. Grigor'ev, V. I.; Rasul, G. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; 13: No. 5, 539-544 (1972). (In Russian).

A semi-classical and quantum field treatment was accorded the process of boson emission (scalar $\pi^0$-meson) produced by a strongly interacting system of fast particle scattering by a nucleus. The boson energy and probability of emission were investigated as functions of the initial parameters of the system. (KSW)

## Particle Invariance Principles and Symmetries

### General

**23406** (LNF-72/101) REDUCIBLE SCALE INVARIANCE AT SHORT DISTANCES. Ferrara, S. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratori Nazionali di Frascati). 30 Nov 1972. 9p. Dep. NTIS (U. S. Sales Only) $3.00.

It is proven that, using reducible scale invariance at short distances, conformal symmetry implies canonical (Bjorken) scaling provided diagonal dimensions of dilatation multiplets occurring in the operator product expansion of two electromagnetic currents have the canonical value $l_n = 2 + n$. If the electromagnetic current itself belongs to such multiplets then the hadron production cross section in $e^+e^-$ annihilation falls off faster than 1/s at asymptotic energy. (auth)

**23407** RELATIVISTIC INVARIANCE AND DISCRETE SYMMETRIES. Balachandran, A. P. (Syracuse Univ., NY). Curr. Sci. (India); 42: No. 5, 149-151(5 Mar 1973).

A method is briefly outlined whereby geometric transformations like rotations and space-time translations are implemented as invariance transformations in quantum mechanics. (LBS)

**23408** GROUP-THEORETICAL ASPECTS OF QUANTUM MECHANICS. Majumdar, S. D. (Indian Inst. of Tech., Kharagpur). Curr. Sci. (India); 42: No. 5, 161-163(5 Mar 1973).

The mathematical problems that arise in connection with the study of structural properties of higher SU(n) groups for elementary particles are divided into the following broad categories: construction of state vectors; determination of the matrices of the generators; determination of the representation matrices for finite transformations; classification and construction of tensor operators; structure of the Clebsch–Gordon series; and evaluation of the Clebsch–Gordon coefficients. The last two problems are discussed in some detail. (LBS)

### Applications (Electromagnetic and Weak)

*Refer also to abstracts 23584 and 23621.*

**23409** REFLECTING PARTICLES AND POSSIBLE MODEL FOR VIOLATION OF C-INVARIANCE. Bedritskii, A. I. (Vitebsk State Pedagogical Inst., USSR). Vestsi Akad. Navuk BSSR, Ser. Fiz.–Mat. Navuk; No. 6, 73-81(1972). (In Russian).

The five-dimensional equations already proposed by the author for a spin of 1/2 describe particles and antiparticles with relative chirality character. They include a hypothesis concerning reflecting particles put forward by other investigators in connection with violation of P- and CP- invariance. The character of some interactions of ordinary and reflecting particles was discussed. Transformations of the C, P, T type were found for five-dimensional equations. In harmony with the model examined, the violation of C-invariance may be evoked by a physical quantity combining hydromagnetic, electrical, and gravitational properties of a particle. A possible violation of C-invariance for positron annihilation was examined. (tr-auth)

### Applications (Strong)

**23410** DERIVATION OF $SU_3$ FROM DUAL MODELS. Dethlefsen, J. M. (Niels Bohr Inst., Copenhagen); Nielsen, H. B. Nuovo Cim.; 14A: No. 1, 85-102(1 Mar 1973).

$SU_3$ is derived from dual models using a smaller number of assumptions than is used in other works. The paper is divided into two parts. In the first part $SU_2$ and $SU_3$ dynamics are derived from realistic 5-point functions. The $SU_3$ particle spectrum, however, has been put in by assuming the mesons to consist of quark-antiquark pairs. In the second part of the work $SU_n$ is derived from the generalized Veneziano model (four-point function with excited legs) using an algebraic method. Duality is shown to be equivalent with the associativity of a certain algebra. (auth)

## Field Theories

### General

**23411** FIELD OF CHARGED, SPINNING, MAGNETIC PARTICLES. Bonnor, W. B.; Ward, J. P. (Queen Elizabeth Coll., London). Commun. Math. Phys.; 28: No. 4, 323-330(1972).

Stationary solutions of the Einstein–Maxwell equations have recently been given corresponding to charged, spinning magnetic matter. A solution for two particles of such matter is given. In general it contains a singularity between the particles. (auth)

**23412** GRAVITATIONAL THEORY IN THE PRESENCE OF SPINORS. Lord, E. A. (Indian Inst. of Science, Bangalore, India). Curr. Sci. (India); 42: No. 5, 157-159(5 Mar 1973).

The theory of spinor fields in interaction with gravitation is described. The massless Dirac equation is modified by the interaction and becomes identical in form with the nonlinear spinor equation that proves the basis of Heisenberg's unified field theory. When applied to electromagnetism the theory leads to an unresolved difficulty connected with charge conservation and the spin-density of electromagnetism. (auth)

### Quantum Field Theory

**23413** (CERN-73-3) VISUAL AIDS TO RELATIVISTIC KINEMATICS. Wick, G. C. (European Organization for Nuclear Research, Geneva (Switzerland)). 12 Feb 1973. 27p. Dep. NTIS (U. S. Sales Only).

The discussion of relativistic kinematics covers the Minkowski velocity manifold, various coordinates, geometry of planes and lines, orthogonality, an example of an inclusive interaction, and a vector calculus for kinematics. (JFP)

**23414** (CF-LPAM-72-9) EFIMOV–FRADKIN FORMALISM FOR NONPOLYNOMIAL INTERACTIONS OF AN HARMONIC OSCILLATOR. II. Interactions Represented By Rational Functions. Houard, J. C.; Teffo, J. L. (College de France, Paris. Laboratoire de Physique Atomique et Moleculaire). Sep 1972. 33p. Dep. NTIS (U. S. Sales Only) $3.75.

The problems raised by the application of the Efimov–Fradkin formalism to rational interaction hamiltonians are examined in the framework of the harmonic oscillator model. It is shown that the concept of the normal product has to be revised, and a new definition is proposed. The amplitudes of the perturbation theory are calculated in the coherent states representation. The expressions obtained are only formally equivalent to the Efimov–Fradkin ones which are divergent. (France)

**23415** (DESY-72/73) THEORIES WITH MASSLESS PARTICLES. Symanzik, K. (Deutsches Elektronen Synchrotron, Hamburg (West Germany)). Dec 1972. 10p. (CONF-720663-2). Dep. NTIS (U. S. Sales Only).

From Meeting on the renormalization of Yang–Mills fields and applications to particle physics; Marseilles, France (19 Jun 1972).

Properties of renormalizable theories with massless particles are discussed emphasizing features that can be obtained correctly only by summing overall orders of perturbation theory, for which it suffices to do with respect to the soft massless particles. (JFP)

**23416** (IFVE-STF-72-32) METHOD OF STRONG COUPLING IN SYMMETRIC PSEUDO-SCALAR THEORY. Tyurin, N. E.; Shurgaya, A. V. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1972. 19p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

N. N. Bogolubov method is used to study the interaction of the symmetric pseudo-scalar field with the nucleon at rest in the strong coupling limit. The scheme of successive approximations for energy and wave function of the system is constructed. The conservation laws of isotopic spin and momentum of the system are strictly taken into account. The isotopic structure of system contained in the Hamiltonian terms proportional to $g^{-2}$ is marked out. (auth)

**23417** (IFVE-STF-72-45) LOW-ENERGY THEOREMS AND DISPERSION RELATIONS IN QUANTUM ELECTRODYNAMICS. Solovev, L. D. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1972. 18p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

The axiomatical Bogolubov approach in the quantum field theory is generalized for the case of taking into account the electromagnetic interaction. The aim of this generalization is to obtain dispersion relations and low-energy theorems to all orders in the electromagnetic interaction. (auth)

**23418** (LNF-72/94) SERIOUS DIFFICULTIES WITH CANONICAL DIMENSIONS. Parisi, G. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratori Nazionali di Frascati). 27 Oct 1972. 5p. Dep. NTIS (U. S. Sales Only) $3.00.

We present a strong nonperturbative argument which implies that the fundamental fields have anomalous dimensions if the interaction is scale invariant. A physical consequence is that Bjorken scaling cannot be present in asymptotically scale invariant field theories. (auth)

**23419** FIELDS, STATISTICS, AND NON-ABELIAN GAUGE GROUPS. Doplicher, S.; (Istituto Nazionale di Fisica Nucleare, Rome); Roberts, J. E. Commun. Math. Phys.; 28: No. 4, 331-348 (1972).

Field theories with a compact group G of exact internal gauge symmetries so that the superselection sectors are labelled by the inequivalent irreducible representations of G are examined. A particle in one of these sectors obeys a parastatistics of order d if and only if the corresponding representation of G is d-dimensional. The correspondence between representations of the observable algebra and representations of G extends to a mapping of the intertwining operators for these representations preserving linearity, tensor products and conjugation. Although no explicit commutation property between fields is assumed, the commutation relations of fields of the same irreducible tensor character under G at spacelike separations are largely determined by the statistics parameter of the corresponding sector. For fields of conjugate irreducible tensor character the observable part of the commutator (anticommutator) vanishes at spacelike separations if the corresponding sector has para-Bose (para-Fermi) statistics. (auth)

**23420** RELATIVISTIC WAVE EQUATIONS OF THE SECOND AND FIRST ORDER. Pletyukhov, V. A.; Fedorov, F. I. (Inst. of Physics, Minsk). Vestsi Akad. Navuk BSSR, Ser. Fiz. Mat. Navuk; No. 6, 59-64(1972). (In Russian).

The ambiguity of the conversion from relativistic wave equations of the second order to equations of the first order was examined. A transition was found to the simplest, that is, possessing the minimum possible number of equations and a wave function component to systems of the first order. (tr-auth)

**23421** RADIATIVE CORRECTION IN QUANTUM ELECTRODYNAMICS. Remiddi, E. (Univ., Bonn). Comput. Phys. Commun.; 4: No. 2, 193-198(Nov 1972).

After a rather long pause, in the last years several new results have appeared (and continue to appear) in the evaluation of higher order radiative corrections to quantum electrodynamics. They found their natural justification in the recent progress in high precision, low energy QED experiments (Josephson-effect measurement of the fine structure constant value and Lamb shift values, gyromagnetic ratios of electron and muon), and became possible on account of the increasing use of large digital computers, which seem to be a common feature of all the recent work in the field. They are reviewed, with special regard to the numerical or symbolic characteristics of the computing techniques used. (auth)

**23422** TWO-PARTICLE BOUND STATES IN A MODIFIED LEE MODEL. Gostev, V. B.; Lesskis, A. G. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; 13: No. 5, 551-557(1972). (In Russian).

Modifications of the Lee model by means of substitutions of commutated Fermi relations for heavy particles for the Bose relation are given. Discrete steady states in sectors with two heavy particles and a random number of light particles were investigated. There was not more than one bound state in each sector. Within the limits of a strong bond, the levels of energy of different two-particle sectors were equidistant. (tr-auth)

**23423** REDUCE APPROACH TO THE CALCULATION OF FEYNMAN DIAGRAMS. Calmet, J. (Univ. of Utah, Salt Lake City). Comput. Phys. Commun.; 4: No. 2, 199-204(Nov 1972).

A brief survey of two existing REDUCE programs (by Campbell–Hearn and by Calmet) dealing with the algebraic computation of Feynman diagrams is given. Work in progress on a more general approach to this problem is discussed. Finally, we consider the impact of REDUCE on high energy physics. (auth)

**23424** EXPECTATIONS IN NORMED *-ALGEBRAS. Kannan, D. (New York Univ., New York). J. Math. Anal. Appl.; 41: No. 1, 14-19(Jan 1973).

A positive hermitian linear functional on a *-algebra with identity is called an expectation when it satisfies a normalizing and an admissibility condition. The main theorem of this note shows that a positive linear function, on a normed *-algebra, with normalizing condition is always an expectation. A simple relation connecting this expectation and the expectation of Nakamura and Turumaru is given. (auth)

## *Gravitation and General Relativity*

**23425** NEW APPROACH TO THE THEORY OF RELATIVITY. Second Edition. Kar, K. C. Calcutta; Institute of Theoretical Physics (1972). 72p. $6.00.

The relativistic problems are treated from a new standpoint. Lorentz transformations, invariance of electromagnetic equations, new conceptions of covariant and contravariant vectors, etc. are established in a simple manner. The problems of perihelion motion of planets and bending of light are solved with the simple theory of relativity without Einstein's conception of curvature in space-time continuum. Red shift is treated nonrelativistically. Acoustical relativity is a new approach to extend relativity to the acoustic world. (LBS)

**23426** GRAVITATIONAL RADIATION AND NEUTRINOS. Griffiths, J. B. (Univ. of Tech., Loughborough, Eng.). Commun. Math. Phys.; 28: No. 4, 295-299(1972).

A class of neutrino-gravitational fields with zero energy-momentum tensor is defined. These space-times may also be interpreted as describing gravitational waves and are of Petrov type D or N. A wave-like example of the latter is given. (auth)

**23427** EINSTEIN–CARTAN EQUATIONS. III. Trautman, A. (Univ., Warsaw). Bull. Acad. Pol. Sci., Ser. Sci., Math., Astron. Phys.; 20: No. 10, 895-896(1972).

An analogue of the Mathisson–Papapetrou equation of motion of a spinning particle is derived from the field equations of the Einstein–Cartan theory of gravity. (auth)

**23428** SYSTEMS OF EQUATIONS OF THE FIRST ORDER FOR A GRAVITON. Krylov, B. V. (Inst. of Physics, Minsk). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Mat. Navuk; No. 6, 82-89(1972). (In Russian).

Four systems of linear differential equations of the first order were obtained from linearized Einstein equation. Two systems of equations were developed, the matrices of which proved to be extremely simple and suitable for formulating a graviton theory. A series of relations between the equation matrices and the infinitesimal operators introduced Lorentz groups in the region of wave functions. (tr-auth)

**23429** MAXWELL–TYPE EQUATIONS IN THE THEORY OF INERTIAL GRAVITATIONAL FIELD. Raigorodski, L. D. (Leningrad Shipbuilding Inst.). Acta Phys. Acad. Sci. Hung.; 33: No. 1, 63-77(1973).

Some problems connected with the possibility of applying Maxwell-type equations in the gravitation theory are discussed. (auth)

**23430** COVARIANT DERIVATION OF THE ELECTROMAGNETIC BOUNDARY CONDITIONS IN GENERAL RELATIVITY. Rawson–Harris, D. (Queen Elizabeth Coll., London). Int. J. Theor. Phys.; 6: No. 5, 339-346(Dec 1972).

The covariant derivation of the electromagnetic boundary conditions seems not to have been given. It is presented here, for general electromagnetic sources and distributions of matter which are independent of time. Thus the boundary conditions are suitable for use in stationary solutions in general relativity. (auth)

**23431** RAINICH CONDITIONS FOR NEUTRINO FIELDS. Collinson, C. D.; Shaw, R. (Univ. of Hull, Eng.). Int. J. Theor. Phys.; 6: No. 5, 347-357(Dec 1972).

The algebraic Rainich conditions for neutrino fields are obtained in terms of an algebraic classification of symmetric second-rank tensors. The differential Rainich conditions are also obtained for all but one class of neutrino fields. The algebraic classification of symmetric second-rank tensors used here is compared to two previously published classifications (Churchill. Trans. American Math. Soc.; 34: 784 (1932) and Plebanski. Acta. Physiologica Polonica; 26: 963 (1964)). The "Weyl square" of a symmetric second-rank tensor is introduced and the Petrov type of the "Weyl square" is used to give a method for determining the class of the symmetric tensor. (auth)

**23432** STATIC SOLUTIONS OF THE BRANS–DICKE EQUATIONS. Buchdahl, H. A. (Australian National Univ., Canberra). Int. J. Theor. Phys.; 6: No. 5, 407-412(Dec 1972).

It is shown that, given any static solution of the Einstein vacuum equations, a corresponding family of static vacuum solutions of the Brans–Dicke equations (Phys. Rev.; 124: 925 (1961)) can be written down by inspection. Spherically and axially symmetric fields are considered explicitly. It is demonstrated how some solutions of the Brans–Dicke equations may be obtained without having to solve any field equations explicitly at all. (auth)

**23433** GRAVITATIONALLY STABILIZED NUCLEONS IN THE THEORY OF THE GENERALIZED GRAVITATIONAL POTENTIAL. Cherry, N. H. Int. J. Theor. Phys.; 6: No. 5, 365-368(Dec 1972).

From the field equation in $\psi$ of the author's general-relativistic scalar field theory in the complex Weyl space an infinite set of Yukawa type equations, representing potential fields, arising from zero rest mass particles is obtained. The simplest of these equations is solved and is used in a nucleon model as the origin of a gravitationally stabilized nucleon. This procedure leads directly to an expression that predicts the representative nucleon radius of 1·21 fm. (auth)

**23434** METHODS OF LOCAL AND GLOBAL DIFFERENTIAL GEOMETRY IN GENERAL RELATIVITY. Proceedings of the Regional Conference on Relativity Held at Pittsburgh, Pennsylvania, July 13–17, 1970. Farnsworth, D.; Fink, J.; Porter, J.; Thompson, A. (eds.). Lecture Notes in Physics. Volume 14. New York; Springer Verlag New York, Inc. (1972). 195p. (CONF-700731–). $5.60.

The conference on general relativity covers topology and differential geometry, general redshift formula, a radiating solution of the Einstein–Maxwell equations, conservation laws on manifolds, singularity structure, lattice transformations and charge quantization, an Einstein–Maxwell field with a null source, and collapsing star luminosity. Also discussed are a class of inextendible Weyl solutions, scaling in function spaces, the spherical symmetry of a static perfect fluid, differentiable manifolds with singularities, nonvacuum ADaM field equations, and general relativity as a dynamical system on a manifold of Riemannian metrics with diffeomorphisms. (JFP)

**23435** TWO-BODY PROBLEM FOR THE METRIC OF NORDTVEDT. Breen, B. (Imperial Coll. of Science and Tech., London). J. Phys., A (London); 6: No. 2, 150-160(Feb 1973).

The postnewtonian n-body equation for the general metric expansion of Nordtvedt is derived. By taking $n = 2$, the advance of the periastron and the motion of the center of mass in the two-body problem are examined. This enables the formulas for these effects to be found in the Brans-Dicke and Nordtvedt scalar-tensor theories. (auth)

**23436** ELASTIC SCHWARZSCHILD SCATTERING CROSS SECTION. Collins, P. A.; Delbourgo, R.; Williams, R. M. (Imperial Coll. of Science and Tech., London). J. Phys., A (London); 6: No. 2, 161-169(Feb 1973).

The differential cross section for scattering from a Schwarzschild source, the analogue of Rutherford scattering is evaluated. The classical formula is compared with the Born approximation. (auth)

## Scattering Theory

*Refer also to abstract 23384.*

**23437** REGULARIZATION OF MULTI-PARTICLE HELICITY AMPLITUDES. Dumitru, D. R. (Inst. of Atomic Physics, Bucharest). Lett. Nuovo Cim.; 6: No. 7, 253-256(17 Feb 1973).

A set of regularized helicity amplitudes for n-particle processes is defined, giving up the usual regularization procedure which relies on the explicit behavior of helicity amplitudes near each singularity surface. Starting with kinematic-singularities-free (KSF) functions which are built from spinor amplitudes and from a given set of suitable covariant polynomials, the KSF functions are written as linear combinations of helicity amplitudes. (LBS)

**23438** OFF-ENERGY-SHELL IMPACT PARAMETER REPRESENTATION. Chavda, L. K. (Univ. of Alberta, Edmonton). Lett. Nuovo Cim.; 6: No. 6, 197-204(10 Feb 1973).

An off-energy-shell amplitude is derived in terms of on-energy-shell phase shifts, using the Lippman–Schwinger equation in the impact parameter space. (LBS)

**23439** VOLUME OF LONGITUDINAL PHASE SPACE. Kajantie, K.; Karimaeki, V. (Univ. of Helsinki). Ann. Acad. Sci. Fenn., Ser. A VI; No. 395, 1-13(1972).

The volume of longitudinal phase space is evaluated approximately by using the saddle point method. The leading term and the first correction term of order $1/n$, $n$ = particle number are included. It is shown that this method works only if $\log E < n$ and the asymptotic form valid for $E \to \infty$ has to be derived by different means. Similar statements concerning the high energy behavior apply also to the phase space integral cut in transverse momenta. (auth)

**23440** SOLUTION OF THE INVERSION PROBLEM FOR NONSPHERICALLY SYMMETRIC SEPARABLE POTENTIALS. Gerber, R. B. (Weizmann Inst. of Science, Rehovoth, Israel). J. Phys., B (London)); 5: No. 12, L242-L245(Dec 1972).

An analytic solution is presented for the problem of construction of a nonspherically symmetric separable potential from scattering data. The input data employed consists of the forward and backward values of the scattering amplitude for all the directions of incidence and at all the energies. The result is a generalization of the solution given by Gourdin and Martin (Nuovo Cim.; 8: 699-707 (1958)) for the spherically symmetric case. Possible applications of effective interactions so determined are briefly discussed. (auth)

**23441** NEW MATHEMATICAL METHODS FOR ANALYZING SOME NONLINEAR PHYSICS PROBLEMS WITH THE AID OF A COMPUTER. Zhidkov, E. P. (Joint Inst. for Nuclear Research Dubna, USSR). Comput. Phys. Commun.; 4: No. 2, 182-185(Nov 1972).

A method being the continuous analog of Newton's method is given for obtaining the solution of some nonlinear physics problems by computers. The physical problems are as follows: that of the extraction of a beam of charged particles from an accelerator and the inverse problems of the scattering theory. (auth)

**23442** GENERALIZATION OF THE KAHANE ALGORITHM FOR SCALAR PRODUCTS OF $\gamma$-MATRICES. Chisholm, J. S. R. (Univ. of Kent, Canterbury, Eng.). Comput. Phys. Commun.; 4: No. 2, 205-207(Nov 1972).

Earlier formulas governing the elimination of single scalar products $\gamma_\alpha \ldots \gamma_\alpha (\alpha = 0, 1, 2, 3)$ of Dirac matrices are reviewed. Kahane's algorithm for eliminating any number of scalar products from a single $\gamma$-matrix "string" is extended to terms consisting of a single string and any number of traces. (auth)

**23443** LOWER AND UPPER BOUNDS FOR THE OVERLAPPING FUNCTIONS AT HIGH ENERGY. Arushanov, G. G. (Physical-Technical Inst., Tashkent). Teor. Mat. Fiz.; 14: No. 2, 180-191(Feb 1973). (In Russian).

Upper and lower bounds for the overlapping function and the imaginary part of the elastic scattering amplitude are obtained in the nonphysical region of the momentum transfer variable $0 < t < 4\mu^2$. Similar inequalities are also established for the derivatives of those functions at $t = 0$. (auth)

**23444** INTEGRAL RELATIONSHIPS BETWEEN THE REAL AND IMAGINARY PARTS OF THE FORWARD SCATTERING AMPLITUDE. Mnatsakanova, M. N. (Moscow State Univ.). Teor. Mat. Fiz.; 14: No. 2, 192-201(Feb 1973). (In Russian).

On the basis of the analyticity and crossing-symmetry requirements, the relation between the integrals over the physical region of the real and imaginary parts of the scattering amplitude is obtained. (auth)

**23445** SOME PROPERTIES OF SCATTERING AMPLITUDES IN THE FRAMEWORK OF THE RELATIVISTIC EQUATION OF DAMPING THEORY. Belov, V. K.; Savrin, V. I.; Tyurin, N. E. (Inst. of High Energy Physics, Serpukhov, USSR). Teor. Mat. Fiz.; 14: No. 2, 277-281(Feb 1973). (In Russian).

Analytic properties of the scattering amplitude are studied in the framework of a relativistic generalization of the main equation of the quantum damping theory. Asymptotic behavior of the Regge trajectories is considered. (auth)

**23446** SEPARATION OF VARIABLES IN THE SPHERO-CONICAL COORDINATE SYSTEM AND THE SCHROEDINGER EQUATION FOR THE CASE OF NONCENTRAL FORCES. Lukach, I.; Smorodinskii, Ya. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Teor. Mat. Fiz.; 14: No. 2, 170-179(Feb 1973). (In Russian).

Separation of variables is considered in sphero-conical system of coordinates connected with the existence of the elliptic coordinate system on three-dimensional sphere. The potential of interest in the class of allowable potentials is that of the form $qr^{-4}[3(\alpha r)(\beta r) - (\alpha\beta)r^2]$, $\alpha$, $\beta$ being two arbitrary unit vectors. The angular part of this potential is of the same form as the angular part of the noncentral interaction of two magnetic dipoles. After reducing the angular part to the principal axes, the solution of the Schrodinger equation with the potential under consideration is reduced to the Lame wave equation. The solutions in the first order of the perturbation theory are given, and the splitting of energy levels of a radially symmetrical field in the presence of this noncentral potential is considered. In particular, such a splitting of energy levels is calculated in the cases of the Coulomb potential and the potential with the quadratic dependence on the radius. (auth)

**23447** LEAST SQUARES METHOD APPLIED TO SCATTERING PROBLEMS. Read, F. H.; Soto-Montiel, J. R. (Univ. of Manchester, Eng.). J. Phys., B (London); 6: No. 2, L15-L19(Feb 1973).

The least squares variational method has been used to calculate s-wave phase shifts in two scattering problems, namely the scattering of a single particle by a square well potential and the elastic scattering of electrons by hydrogen atoms. (auth)

**23448** AXIOMATIC SCATTERING THEORY. Fateev, V. A.; Shvarts, A. S. (Moscow Engineering-Physics Inst.). Teor. Mat. Fiz.; 14: No. 2, 152-169(Feb 1973). (In Russian).

The conditions are pointed out, under which the scattering matrix can be constructed starting from the asymptotically abelian operator algebra. Various definitions of the scattering matrix are proposed, and their equivalence to each other is proved. (auth)

# PHYSICS (LOW-TEMPERATURE)

## Superfluidity

**23449** SURFACE CONTRIBUTION TO THE SPECIFIC HEAT OF He II FILMS. Chan, S. L. (Univ. of Sussex, Eng.). J. Low Temp. Phys.; 10: No. 1-2, 225-230(Jan 1973).

The surface contribution to the specific heat of saturated and unsaturated He II films was considered. The temperature dependence of the surface-contributed specific heat is found to depend on the range of temperatures as well as the film thickness under consideration. A comparison with earlier results is made, and it is found that those results are not consistent with the specific heat contributed by the capillary wave modes of the free surface. (auth)

**23450** TWO-ROTON MODEL IN LIQUID HELIUM II. Takeno, S. (Kyoto Univ.). Progr. Theor. Phys. (Kyoto); 48: No. 6A, 2107-2109(Dec 1972).

A two-roton model is proposed as a possible scheme to understand the nature of rotons in liquid helium II. To study the nature of rotons further on, a detailed analysis is made of the recent experimental results obtained by Dietrich, et al., (Phys. Rev. A5: 1377(1972)). (MHR)

**23451** MICROSCOPIC THEORY OF IMPURITIES IN LIQUID HELIUM. III. Bowley, R. M. (Univ. of Nottingham, Eng.). J. Low Temp. Phys.; 10: No. 3-4, 481-501(Feb 1973).

The theory of the polaron based on path integrals is used to discuss the motion of an impurity in liquid helium. A model Hamiltonian is introduced in which the interaction between the phonons and the impurity depends on two parameters. The mobility equations are solved in two approximations for the recoil motion of the ion. The real part of the frequency-dependent mobility comes from the radiation of phonons as well as the scattering of phonons. Three possible solutions are found for the frequency-dependent mobility using one of these approximations. This corresponds to the impurity having three different effective masses. The motion of an ion in a high electric field is calculated. For velocities greater than the Landau critical velocity the ion continuously radiates rotons. The motion of the ion for velocities less than the critical velocity is also calculated. (auth)

**23452** DISTRIBUTION OF FLOW RATES IN THE HELIUM II FILM. Turkington, R. R.; Harris-Lowe, R. F. (Royal Military Coll., Kingston, Ont.). J. Low Temp. Phys.; 10: No. 3-4, 369-377(Feb 1973).

New rate measurements of the flow of the saturated helium film out of a Pyrex beaker, employing a capacitance depth gauge technique, were obtained. The high resolution has allowed us to observe the occurrence of transitions as small as 1½% of the flow rate. Such transitions are much smaller than any previously observed or expected from earlier measurements, which resulted in a preferred flow-rate hypothesis. Even so, the results do establish that some form of a preferred flow-rate structure is a fundamental feature of helium-film transport. (auth)

**23453** SPIN DIFFUSION COEFFICIENT OF $^3$He IN $^3$He–$^4$He SOLUTIONS. Chang, D. C.; Rorschach, H. E. (Rice Univ., Houston, TX). J. Low Temp. Phys.; 10: No. 1-2, 245-266(Jan 1973).

The transport properties of $^3$He in $^3$He–$^4$He solutions with molar concentrations of 5, 9, 14, and 24% were studied for $0.9\ K \leq T \leq 2.5\ K$. The spin diffusion coefficient $D_s$ and the longitudinal relaxation time $T_1$ were measured by the spin-echo method for temperatures both above and below the solution lambda temperature $T_\lambda$. The spin-echo method measures the diffusion coefficient for magnetization $D_s$, which differs from the usual diffusion coefficient for particles D below $T_\lambda$. $D_s$ depends on the $^3$He–$^3$He scattering cross section $\sigma_{FF}$ and the $^3$He–roton/phonon cross section $\sigma_{FB}$, while D depends only on $\sigma_{FB}$. The distinction between $D_s$ and D is elaborated in terms of a simple mutual-friction model for diffusion. The two scattering mechanisms are clearly evident in the behavior of $D_s$ as a function of concentration x and temperature. The contribution due to the $^3$He–$^3$He scattering is inversely proportional to x, indicating that the $^3$He can be treated in first approximation as a classical gas (the Pomeranchuk model). The predictions of various theoretical models are compared with the results, where possible, but most of the previous theoretical work is not applicable to the concentration range and temperatures of these measurements. (auth)

**23454** ABSORPTION OF FOURTH SOUND IN He II NEAR THE λ POINT. Sanikidze, D. G. (Inst. of Cybernetics, Tbilisi, USSR). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1919-1921(Nov 1972). (In Russian).

The various mechanisms of absorption of fourth sound near the λ-point are investigated. It is shown that the major mechanism of energy dissipation is decay of fourth sound into second sound quanta with wavelengths of the order of the correlation length. The sound absorption coefficient is calculated and its temperature dependence near the λ-point is determined. (auth)

**23455** SUPERFLUID COMPONENT DENSITY DISTRIBUTION NEAR THE He I–He II PHASE INTERFACE IN EXTERNAL FIELDS. Sobyanin, A. A. (Inst. of Physics of High Pressures, Moscow). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1780-1792(Nov 1972). (In Russian).

Distribution of the order parameter (density of superfluid component) near the He I–He II phase interface in external fields is investigated on basis of two modified variants of the Ginzburg–Pitayevsky phenomenological theory of superfluidity. Results of a numerical solution of the respective equations are presented for three types of external fields: for a gravitational field, the field of the van der Waals forces near a rigid wall and the field of a point electric charge (ions in helium). (auth)

**23456** OBSERVATIONS ON THE USE OF SINTERED COPPER HEAT EXCHANGERS IN EXPERIMENTS WITH SUPERFLUID HELIUM. Bertinat, M.; Brewer, D. F.; Butterworth, G. J. (Sussex Univ., Brighton, Eng.). Cryogenics; 13: No. 1, 48-49(Jan 1973).

During experiments to measure the viscosity of dilute $^3$He–$^4$He solutions with a cryostat, it was found that high and erratic results were obtained. These effects were found to be due to the retention of liquid $^4$He in the sinter block. From this evidence it would appear that superfluid $^4$He can be held at a higher gravitational potential than the free liquid surface. The detailed mechanism of this effect is considered but no definite conclusions are reached but a warning is given that from a practical point of view it is essential that great care should be taken in the use of sintered copper heat exchangers, both with pure helium and with solutions, when it is vital to know the amounts of helium distributed in various parts of the system. (UK)

**23457** DYNAMICS OF ROTONS. Robert, P. H.; Donnelly, R. J. (Niels Bohr Inst., Copenhagen). Phys. Lett., A; 43A: No. 1, 1-2 (12 Feb 1973).

It is shown that point dipoles in a superfluid obeying the Landau dispersion relation for rotons can form stable bound states. Structure is added to the roton model by adding the octupole moment appropriate to a vortex ring. The binding energy is then computed to be 0.337°K. Scattering appears to be satisfactorily accounted for by the dipole approximation. (auth)

## Superconductivity

**23458** (IS-M-2) EFFECT OF ALLOYING ON THE SUPERCONDUCTING TEMPERATURE OF $La_3In$. Gschneidner, K. A. Jr.; McMasters, O. D.; Ostenson, J. E. (Ames Lab., Iowa). [nd]. 7p. (CONF-730402-5). Dep. NTIS.

From 10th rare earth research conference; Carefree, Arizona, USA (30 Apr 1973).

Present alloying studies involved (1) the addition of small nonmetallic elements to $La_3In$ ($Cu_3Au$-type structure) to form the antiperovskite compounds, (2) the substitution of large metallic elements for lanthanum, and (3) the substitution of small metallic elements for indium. Carbon additions and tin and rare earth (Y, Ce, Gd) substitutions lower the superconducting transition temperature of $La_3In$. Oxygen and silicon additions and aluminum substitutions raise the transition temperature. Within experimental error boron has no effect. (auth)

**23459** (IS-T-573) CRITICAL FIELD CURVES FOR THE ThU ALLOY SYSTEM. Watson, H. L. (Ames Lab., Iowa). Feb 1973. Contract W-7405-eng-82. 162p. Dep. NTIS $10.25. Thesis.

The superconducting critical field curves were measured for the the ThU alloy system and were found to be in agreement with the BCS theory critical field curves to an accuracy of 1%, thus providing additional experimental evidence that the rapid depression of the superconducting transition temperature of pure thorium by the uranium impurities is due to pair-weakening rather than to pair-breaking mechanisms. Additional experimental evidence is provided by the fact that the reduced specific heat jumps at $T_c$ for these alloys, obtained from the slope of the superconducting critical field curves and Rutger's formula, are also in close agreement with the BCS theory. Within the accuracy of the experimental data, the electronic specific heat coefficient, $\gamma$, remains essentially constant. (auth)

**23460** (ISS-72/5) MAGNETIC FIELD DEPENDENCE OF THE MICROWAVE PROPERTIES OF Pb SUPERCONDUCTIVE FILMS. Part I. Di Crescenzo, E.; Indovina, P. L.; Onori, S.; Rogani, A. (Istituto Superiore di Sanita, Rome (Italy). Laboratori di Fisica). 26 Apr 1972. 38p. (In Italian). Dep. NTIS (U. S. Sales Only) $4.00.

The first of two reports concerning magnetic properties of superconducting films is presented. The problem is the behavior of critical magnetic fields in thin and thick films and also in the more interesting situation when the film thickness is of the same order as the microscopic quantities of the superconductor. In addition to this, the dependence of $t_{H_{c_3}}$ on the film thickness is studied. Measurements are reported on a 15,000 Å Pb sample showing the information obtained by means of a high sensitivity differential technique working in the microwave range. (auth)

**23461** (ISS-72/6) MAGNETIC FIELD DEPENDENCE OF THE MICROWAVE PROPERTIES OF Pb SUPERCONDUCTIVE FILMS. Part II. Di Crescenzo, E.; Indovina, P. L.; Onori, S.; Rogani, A. (Istituto Superiore di Sanita, Rome (Italy). Laboratori di Fisica). 28 Apr 1973. 36p. (In Italian). Dep. NTIS (U. S. Sales Only) $4.00.

The second of two reports concerning magnetic properties of superconducting film is presented. The results, which are in good agreement with the Ginzburg—Landau theory, are summarized as follows: (a) dependence of the critical magnetic field $H_{cF}$ on the sample thickness; general semiempirical expression valid for any $d/\lambda(t)$ ratios; (b) variation of the penetration depth with the film thickness; (c) study of the order of the phase-transition as a function of the magnetic field at various temperatures and sample thickness. (auth)

**23462** (KFK-1683) MAGNETIZATION MEASUREMENTS OF SUPERCONDUCTING NbTi, NbZr, $Nb_3Sn$, AND $V_3Ga$ MATERIALS AT 4.2 K. Krebs, K. R.; Pytlik, J.; Seibt, E. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik). Dec 1972. 39p. (In German). Dep. NTIS (U. S. Sales Only) $4.00.

Magnetization measurements are described of wire or tape materials of high-field superconductors NbTi, NbZr, $Nb_3Sn$ and $V_3Ga$ used in magnet development at 4.2 K and 4 T. The geometry dependence of magnetization for NbTi multicore conductors with filament diameters between 4 and 48 μm was measured up to 4 T applied magnetic induction. The influence of mixing matrix materials on the magnetization was investigated for NbTi with Cu/CuNi-matrix. The hysteretic losses of the superconducting materials were deduced by a planimetry method. The hysteretic losses normalized to the critical current densities show a nearly linear increase with increasing filament diameters. The experimental results are compared with theoretical calculations based on a modified BEAN model. The comparison shows only qualitative agreement. (auth)

**23463** DESCRIPTION OF SUPERCONDUCTIVITY IN TERMS OF DIELECTRIC RESPONSE FUNCTION. Kirzhnits, D. A.; Maksimov, E. G.; Khomskii, D. I. (Lebedev Inst. of Physics, Moscow). J. Low Temp. Phys., 10: No. 1-2, 79-93(Jan 1973).

A critical temperature $T_c$ of a superconducting transition is calculated for a rather general form of the electron—electron interaction. It is shown that even if both the energy and momentum dependence of the interaction are included, the equation determining $T_c$ coincides formally with the corresponding equation of the BCS theory. The kernel of this equation is a smooth real function of its variables; it is expressed through $\rho(k,E)$, the spectral density of the inverse dielectric function of the system. The expression for $T_c$ is written in terms of $\rho(k,E)$; this enables us to analyze the dependence of the critical temperature on the properties of the metal in a normal state. Some simple models illustrating the results are considered, and a discussion of the limits on $T_c$ is given. (auth)

**23464** PLASTICITY OF LEAD SINGLE CRYSTALS IN THE SUPERCONDUCTING AND NORMAL STATES AT 4.2 K. Kostorz, G. (Institut Max von Laue—Paul Langevin, Grenoble, France). J. Low Temp. Phys.; 10: No. 1-2, 167-183(Jan 1973).

The flow stress increment $\Delta\tau_{SN}$ associated with a superconducting—normal phase transition was studied as a function of deformation and strain rate for several lead single crystals at 4.2 K. In the linear work hardening range, the total applied stress $\tau_S$ determines the size of $\Delta\tau_{SN}$. The dislocation inertial model recently proposed by Granato for the enhanced plasticity of the superconducting state is evaluated in detail with respect to the dependence of $\Delta\tau_{SN}$ on the distance between obstacles to dislocation movement. Reasonable agreement between theory and experimental results is obtained for the linear work hardening range, if it is assumed that the obstacles are forest dislocations. For the normal-state electronic drag coefficient a value $B_{eN} \simeq 1.1 \times 10^{-4}$ dyn · sec/cm$^2$ is estimated. (auth)

**23465** EFFECTS OF ROTATION AND GRAVITY ON SUPERCONDUCTORS. Leung, M. C. (Univ. of Toronto). J. Low Temp. Phys.; 10: No. 1-2, 151-155(Jan 1973).

The internal electric fields, which are induced by rotation and the earth's gravitational field, produce in turn inhomogeneous changes in the transition temperatures of superconductors. It is shown that such changes are within the power of observation in the case of rotation. This effect of inhomogeneity, traditionally neglected in the theory of rotating superconductors, provides a basic distinction between rotation which is a real quantity and the vector potential (of a homogeneous magnetic field) which is defined only within an arbitrary choice of a gauge. (auth)

**23466** THEORY OF THE JOSEPHSON EFFECT IN PURE SNS JUNCTIONS. Svidzinskii, A. V.; Antsygina, T. N.; Bratus, E. N. (Physical—Technical Inst. of Low Temperatures, Kharkov). J. Low Temp. Phys.; 10: No. 1-2, 131-136(Jan 1973).

In previous work Svidzinskii, et al, [Zh. Eksperim. i Teor. Fiz. 61, 1612 (1971)] gave a simple method of finding Green functions for an SNS sandwich. The usual model was considered where the effective masses and Fermi velocities are the same both in the superconductors and in the normal metals, the only differences lying in the values of the effective interaction constants that are zero in the normal and negative in a superconducting metal. The magnetic field produced by the current was ignored. Finally, the ordering parameter modulus was assumed equal in all points of a superconductor up to the boundary. Kulik [Zh. Eksperim. i Teor. Fiz. 57, 1745 (1969)] considered this problem and obtained results that differ with Svidzinskii's. Here, an attempt is made to clarify the discrepancy between the results of Kulik and Svidzinskii. Using Kulik's method, the results of Svidzinskii were obtained. It is shown that this result appears due to canceling discrete and continuous spectra states contributing to the current, so the difference of relatively large terms becomes small. (MHR)

**23467** RIGHI—LEDUC EFFECT IN THE MIXED STATE OF A PURE TYPE-II SUPERCONDUCTOR. Stephan, C. H.; Maxfield, B. W. (Cornell Univ., Ithaca, NY). J. Low Temp. Phys.; 10: No. 1-2, 185-191(Jan 1973).

Measurements of the Righi—Leduc effect, the thermal analog of the Hall effect, in the mixed state of pure niobium are reported. The transverse temperature gradient is approximately field independent above $H_{c1}$. The thermal Hall angle has a strong field dependence near $H_{c2}$. Comparison is made between these data and existing Hall effect measurements in the mixed state. (auth)

**23468** TRANSITION TO ZERO DIMENSIONALITY IN GRANULAR ALUMINUM SUPERCONDUCTING FILMS. Deutscher, G.; Fenichel, H.; Gershenson, M.; Gruenbaum, E.; Ovadyahu, Z. (Tel-Aviv Univ., Ramat Aviv, Israel). J. Low Temp. Phys.; 10: No. 1-2, 231-243(Jan 1973).

Granular aluminum films prepared by evaporation in the presence of oxygen show two different behaviors when the oxygen content is increased. First, the average grain size (as measured by the dark-field electron microscopy technique) is reduced and the critical temperature is increased. This increase is neither due to a variation of the lattice parameter which, following our measurements, stays constant and equal to the value of pure Al, nor to a purely electronic effect linked to the small grain size, because in this first regime the grains are essentially in good electrical contact. In a second stage, the average grain size changes little but the mean free path becomes much smaller than the grain size, indicating a build up of insulating barriers between the grains. The critical temperature decreases and the transition becomes broader as the normal-state resistivity increases. This behavior is attributed to the appearance of large critical fluctuations, due to the fact that the decoupled grains tend to have a zero dimensionality. (auth)

**23469** PREPARATION OF THIN FILMS OF B-1 STRUCTURE SUPERCONDUCTING TERNARY COMPOUNDS. Gavaler, J. R.; Janocko, M. A.; Jones, C. K. (Westinghouse Research Labs., Pittsburgh). J. Vac. Sci. Technol.; 10: No. 1, 17-19(1973).

NbN, a binary B-1 structure superconducting compound, has been successfully prepared in thin film form by a high-purity sputtering process [J. R. Gavaler, J. K. Hulm, M. A. Janocko, and C. K. Jones, J. Vac. Sci. Technol. 6, 177 (1969)]. Here, the deposition of ternary compounds is reported, based on NbN, using a similar technique. The inclusion of a third element, such as carbon, titanium, or zirconium into the NbN structure was accomplished by sputtering in an argon–nitrogen atmosphere from a two-element target. These targets were made either by hot pressing a powder mixture of the elements into a proper form or by welding together two metal sheets into a single unit. Superconducting transition temperatures of $\gtrsim$17 K have been obtained in both Nb–C–N and Nb–TiN thin films by depositing these films at very high temperatures. However, critical current and field data measured at 4.2 K showed that the use of very high substrate temperatures also caused a deleterious effect on these properties. (auth)

**23470** SUPERCONDUCTING PROPERTIES AND STRUCTURE OF REACTIVELY SPUTTERED NIOBIUM CARBIDE THIN FILMS. Spitzer, H. J. (Army Mobility Equipment Research and Development Center, Fort Belvoir, VA). J. Vac. Sci. Technol.; 10: No. 1, 20-21(1973).

Niobium carbide thin films were sputter deposited in a reactive argon and methane plasma at substrate temperatures of 700°C. The background pressure prior to sputtering was typically in the low $10^{-7}$-Torr range, the total sputtering pressure was maintained at $2 \times 10^{-3}$ Torr and the partial pressure ratios of argon and nitrogen were monitored and controlled with a residual gas analyser. $J_c$–H characteristics were measured by applying a pulsed field and pulsed current method and transition temperatures were determined by recording resistivity versus sample temperature. The structure was studied by x-ray diffraction. $H_{c2}$ is about 40 kOe and the highest $T_c$ is 9.6 K. Several carbide phases and their mixtures were observed and have been correlated to the partial pressure ratios of the plasma. (auth)

**23471** FLUCTUATION CONDUCTIVITY IN THE VICINITY OF THE SUPERCONDUCTING TRANSITION. Larkin, A. I.; Ovchinnikov, Yu. N. (Inst. of Theoretical Physics, Moscow). J. Low Temp. Phys.; 10: No. 3-4, 407-421(Feb 1973).

The conductivity of the metal in the vicinity of the superconductivity transition point was obtained. The nonlinear fluctuation effects change the temperature dependence of the conductivity in a wide range of temperatures, in which fluctuation corrections to thermodynamic quantities are still small. At comparatively strong pair breaking these effects decrease the fluctuation correction, which may exceed the conductivity of normal metal far from the transition temperature. (auth)

**23472** SUPERFLUID DENSITY NEAR THE λ POINT OF $^4$He UNDER PRESSURE. Ikushima, A.; Terui, G. (Tokyo Univ.). J. Low Temp. Phys.; 10: No. 3-4, 397-405(Feb 1973).

The superfluid density in $^4$He was determined near $T_\lambda$ from the second-sound velocity as a function of $T_\lambda - T$ and pressure. The critical exponent of the superfluid density was found to depend, even slightly, on the pressure. Furthermore, the fundamental length $\xi_0$ in the coherence length $\xi = \xi_0[1-(T/T_\lambda)]^{-\nu'}$ seemed to be proportional to the mean interatomic distance. The implications of the results are also discussed. (auth)

**23473** AMPLITUDE-DEPENDENT INTERNAL FRICTION IN SUPERCONDUCTING AND NORMAL INDIUM. Platkov, V. Ya.; Polunina, L. N.; Startsev, V. I. (Physical-Technical Inst. of Low Temperatures, Kharkov). J. Low Temp. Phys.; 10: No. 3-4, 359-367(Feb 1973).

The results of the dislocation amplitude-dependent ultrasonic attenuation studies in normal and superconducting indium are presented. The measurements were taken by the pulse method with longitudinal oscillations of 7.5 Mcs/sec. Amplitude-dependent attenuation is represented by a saturation curve. Amplitude-dependent attenuation measured at fixed amplitude in the superconducting state grows with a decreasing temperature in the range 3.4 to 1.8 K and then drops below 1.8 K. In the normal state it does not show any temperature variation. The results indicate that the condition of dislocation unpinning are more favorable in the superconducting state than in the normal and that electronic damping factor does not depend on temperature in the normal state. It is in fair agreement with the theories of electronic drag of dislocation developed by Kravchenko and Holstein. (auth)

**23474** STRUCTURE AND SUPERCONDUCTING TRANSITIONS OF SOME PSEUDOBINARY β–W ALLOYS. Hatt, B. A.; Page, J. K. R.; Rivlin, V. G. (Fulmer Research Inst. Ltd., Stoke Poges, Eng.). J. Low Temp. Phys.; 10: No. 3-4, 285-298(Feb 1973).

A systematic investigation was made of the pseudobinary "β–W" solid solutions $V_3Si-V_3Ge$, $V_3Ge-V_3Sn$, $V_3Ge-V_3Sb$, and $V_3Si-V_3Ga$. The superconducting transition temperatures were measured and the results correlated with metallurgical structures. It is suggested that the alloys show an additive variation of $T_c$ between the binary endpoints and that they deviate from additivity only as a result of nonstoichiometry or disorder. The general trends in the behavior of the pseudobinary vanadium alloys are compared with those of similar niobium alloys. (auth)

**23475** STRUCTURE AND SUPERCONDUCTING BEHAVIOR OF SOME V–Al BINARY ALLOYS AND OF TERNARY β–W ALLOYS BASED ON THE V–Al SYSTEM. Hatt, B. A.; Page, J. K. R.; Rivlin, V. G. (Fulmer Research Inst. Ltd., Stoke Poges, Eng.). J. Low Temp. Phys.; 10: No. 3-4, 271-284(Feb 1973).

Results are given for the structure and superconducting behavior of binary V–Al alloys and of "β–W" ternary alloys based on $V_3X-V_3Al$ where X = Si, Ge, Sn, Ga, and Sb. No "β–W" phase was observed in the binary V–Al system at 25 at. % Al. Instead the alloys were bcc. However, some evidence was found for a martensitic transformation in alloys rapidly quenched from high temperatures. Solid solubility of Al in the "β–W" phase $V_3X$ was restricted as would be expected from the absence of a binary "β–W" $V_3Al$ phase. The superconducting transition temperatures varied systematically with composition in a manner consistent with the phase structure of the alloys. (auth)

**23476** DEPENDENCE OF THE CRITICAL CURRENT OF $Nb_3Sn$ TAPES ON THE DIRECTION OF A TRANSVERSE MAGNETIC FIELD. Jerge, M.; Takacs, S. (Electrotechnical Inst., Bratislava). J. Low Temp. Phys.; 10: No. 3-4, 469-479(Feb 1973).

A theoretical and experimental study was made of the critical current of $Nb_3Sn$ tapes prepared by different methods as a function of direction and magnitude of the applied transverse magnetic field. For different orientations of the magnetic field with respect to the crystal grains the pinning is calculated for hypothetical sinusoidal and ellipsoidal shapes of the grains. By comparing the theoretical and experimental results it is concluded that for diffusion-processed $Nb_3Sn$ tapes the grains are almost ellipsoidal, whereas for vapor-deposited tapes they are more sinusoidal. Finally, the possibility of formation of such grain shapes in the process of their creation is explained. (auth)

**23477** ANGULAR DEPENDENCE OF THE RESISTIVE TRANSITIONS IN SUPERCONDUCTING FILMS IN A MAGNETIC FIELD. Aomine, T.; Rinderer, L. (Univ., Lausanne, Switzerland). J. Low Temp. Phys.; 10: No. 3-4, 527-539(Feb 1973).

The resistive transitions above $H_c$ on Al films with the thickness $d < \xi(0)$ were measured as a function of the angle $\theta$ between the film surface and the magnetic field, where $\xi(0)$ is the coherence length at 0 K. An observed broadness in the transitions is considered to be due to fluctuations above $H_c$ and is compared with Aoi's theories taking into account the Aslamazov–Larkin (AL) contribution only, or both the AL and an anomalous (Maki) contribution. At all angles the observed electrical conductivity due to fluctuations $\sigma'$ is larger than the theoretical predictions based on the AL contribution alone. Except for angles near $\theta = 0$, the observed $\sigma'$ can be explained by adding the anomalous contribution to that of AL. (auth)

**23478** TYPE-II SUPERCONDUCTORS WITH A FIRST-ORDER TRANSITION AT THE LOWER CRITICAL FIELD. Jacobs, A. E. (Univ. of Toronto). J. Low Temp. Phys.; 10: No. 1-2, 137-150 (Jan 1973).

The free energy of a superconductor in the mixed state is obtained to first order in $1 - (T/T_c)$ and $\kappa - (1/\sqrt{2})$ in terms of the solutions of the Ginzburg–Landau equations for $\kappa = 1/\sqrt{2}$. The circular cell approximation is used to evaluate the lower critical field and the discontinuity in the magnetization at this field for those type-II materials displaying a first-order transition at the field of first flux penetration; the cases of both singly quantized and doubly quantized vortices are considered. The main result of the numerical calculations is that the critical value of $\kappa$ for a first-order transition is identical to the critical value of $\kappa$ for an attractive interaction between widely separated vortices. (auth)

**23479** SUPERCONDUCTIVITY IN THE HIGH-PRESSURE PHASES OF BARIUM. Moodenbaugh, A. R. (Univ. of California, San Diego, La Jolla); Wittig, J. J. Low Temp. Phys.; 10: No. 1-2, 203-206(Jan 1973).

The superconducting transition temperature of barium was redetermined as a function of pressure. The results are at variance with the work of Il'ina and Itskevich. Apparently mixed phase samples occurred rather generally. It is thought that at least the overall shape of the pressure dependence of $T_c$ has been correctly determined. (auth)

**23480** OPERATION OF A FRANK–READ SOURCE IN A SUPERCONDUCTOR. Bar'yakhtar, V. G.; Druinskii, E. I.; Fal'ko, I. L. (Kharkov State Univ.). Sov. Phys. Solid State (Engl. Transl.); 14: No. 7, 1707-1710(Jan 1973).

Translated from Fiz. Tverd. Tela; 14: No. 7, 1972-1976(Jul 1972).

Operation of a Frank–Read source in an ideal superconductor is considered. Under a constant load the velocity of a dislocation loop generated by this source and the reduced nucleation period of such a loop $\tau_s/\tau_n$ (the subscripts "s" and "n" refer to the superconducting and normal states, respectively) are functions of the temperature and the applied external stress $\sigma$. The temperature and stress dependences are derived for the "stress softening effect," which is necessary for the maintenance of the constant rate of operation of a Frank–Read source. The theoretical results are shown to be supported by the experimental data. (auth)

**23481** TUNNELLING OF EXCITATIONS FROM A SUPERCONDUCTOR AND THE INCREASE OF $T_c$. Aronov, A. G.; Gurevich, V. L. (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1809-1821(Nov 1972). (In Russian).

A nonequilibrium state of a superconductor due to tunnel transitions is studied. In this state both the total number of superconducting excitations as well as their energy distribution vary (decrease). This should lead to an increase of $T_c$ since the critical temperature depends on the number of excitations, as well as on their distribution. A double tunnel structure is considered which consists in a superconducting film, each surface of which is covered by a dielectric layer. Two semiconductors of the p- and n-type are in contact with the latter. During tunnel transitions holes under the superconductivity gap enter the n-material, whereas quasiparticles from the region above the gap enter the p-material. Their decrease is compensated by excitation-hole pair production by phonons. The total excitation concentration in this case decreases. (auth)

**23482** SUPERCONDUCTOR LOSSES IN A PULSING MAGNETIC FIELD. Bronca, G. (Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France); Hlasnik, I.; Lefrancois, C.; Pouillange, J. P. Elektrotech. Cas.; 23: No. 10, 681-709(1972).

A complex survey is presented of the theory of losses in hard superconductors placed in a pulsing magnetic field, of measuring methods of these losses and a comparison of experimental results with theoretical conclusions. This survey is based mainly on the original work performed by the authors in the Saturne Department of the Centre d'Etudes Nucléaires at Saclay. (auth)

**23483** PROPERTIES OF SUPERCONDUCTING MATERIALS. Il'chev, A. I.; Molotilov, B. V.; Suvorov, V. A.; Fedotov, L. N.; Shiryaev, Yu. P. Sb. Tr. Tsent. Nauch.-Issled. Inst. Chern. Met.; No. 78, 108-110(1971). (In Russian).

The technical and physico-mechanical properties of superconducting materials developed in the USSR are given and recommendations made for their use. The alloys include 65BT, 50BT, 35BT (as wires); 70B (strip); and SKM (composite). Superconducting wire is prepared from Nb–Ti–Zr alloys containing the indicated Nb (i.e., 65BT, 50 BT, 35BT–65, 50, and 35% respectively), Zr 2 to 11%, and Ti remainder, in 0.27 ± 0.02 mm dia form with a 0.04 mm Cu coating. These materials have been used for magnetohydrodynamic generators, super high-frequency equipment, solenoids for magnetic fields of $>6.4 \times 10^6$ A/m (80 kOe), etc. (Metals Abstr.)

**23484** THERMODYNAMIC PROPERTIES OF THIN TWO-ZONE SUPERCONDUCTING FILMS WITH PARAMAGNETIC IMPURITIES. Botoshan, N. I.; Kolpazhiu, M. K. (Inst. of Applied Physics, Kishinev, USSR). Fiz. Metal. Metalloved.; 34: No. 5, 899-904(1972). (In Russian).

Thin two-zone superconducting films with paramagnetic additives were theoretically investigated during the flow in them of a constant, uniform electric current. At T = 0, and for "large" concentrations of impurities, expressions were obtained for ordering parameters in dependence on the velocity of electron pairs. The critical current density and magnetic field were calculated for these same conditions. (tr-auth)

**23485** TUNNELING MEASUREMENT OF THE SUPERCONDUCTING ENERGY GAP IN $NbSe_2$. Morris, R. C.; Coleman, R. V. (Univ. of Virginia, Charlottesville). Phys. Lett., A; 43A: No. 1, 11-12(12 Feb 1973).

$NbSe_2$/C/Pb and $NbSe_2$/C/In tunnel junctions with carbon barriers 20 to 200 Å thick were used to determine the energy gap $\Delta_{NbSe_2}$. The average value obtained for tunneling perpendicular to the layers was $2\Delta_{\parallel c} = 1.24 \pm 0.04$ MeV. Magnetic field dependence and anisotropy was discussed. (auth)

**23486** INFLUENCE OF NICKEL ON THE SUPERCONDUCTING PARAMETERS OF $Nb_3Al$ + Ni. Alekseevskii, N. E.; Nizhankovskii, V. I.; Shamrai, V. F.; Bazan, Ch.; Troinar, E. Fiz. Metal. Metalloved.; 34: No. 5, 972-976(1972). (In Russian).

The influence of small quantities of Ni on the critical temperature, magnetization curves, and temperature dependence of the critical magnetic field of $Nb_3Al$ was studied. About 0.2 wt % of Ni produced a small maximum in the critical temperature ($T_{cr}$) curve, additional Ni up to 1.0 wt % caused a rather rapid drop in $T_{cr}$. Similarly, other parameters were lowered by the presence of Ni; this was associated with a decrease in the density of the states. (KSW)

**23487** SUPERCONDUCTIVITY, KNIGHT SHIFT, AND PARAMETERS OF $V_3Si_xGe_{1-x}$ COMPOUNDS. Tret'yakov, B. N.; Kuritsin, V. B.; Kodess, B. N. Fiz. Metal. Metalloved.; 34: No. 5, 1094-1095(1972). (In Russian).

The quasibinary system of intermetallic compounds $V_3Si_xGe_{1-x}$ was single-phase over the range of 0 to 100% $V_3Ge$. Crystal lattice parameters and the superconducting transition temperatures were determined over this concentration range (0 to 100% $V_3Ge$) for the compounds $V_3Si_xGe_{1-x}$. Similarly, the Knight shift of the nuclear magnetic resonance of $^{51}V$ was determined as a function of $V_3Ge$ concentration. (KSW)

**23488** SUPERCONDUCTIVITY OF THIN FILMS OF LEAD. Postnikov, V. V.; Zolotukhin, I. V. (Voronezh Polytechnic Inst., USSR). Fiz. Metal. Metalloved.; 34: No. 5, 1096-1098(1972). (In Russian).

The electrical resistance and the superconducting transition temperatures of Pb films 20 to 1000 Å thick were measured over the temperature range 4.2 to 300°K. The purity of the Pb was 99.9997%. Freshly prepared films possessed lower critical temperatures than the metal in the massive state. The resistance curves, R(f(T)), were sharply discontinuous, and are discussed in terms of film thickness. (KSW)

## Equipment and Devices

*Refer also to abstracts 23043 and 23456.*

**23489** (IAE-2151) COMPUTER CALCULATION OF THE MAGNETIC FIELDS AND FORCES IN THE CYLINDER SOLENOIDS. Klimenko, E. Yu.; Ozhogina, V. K. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Atomnoi Energii). 1971. 16p. (In Russian). INIS.

Methods for the calculation of magnetic fields and forces in cylindrical superconducting magnetic systems were presented. The program formulated in the Algol language made it possible to calculate magnetic systems with continuously variable current density along the radius. (tr-auth)

**23490** (IPP-4/95) VARIABLE TEMPERATURE CRYOSTAT FOR STUDYING SUPERCONDUCTORS. Amenda, W. (Max-Planck-Institut fuer Plasmaphysik, Garching (West Germany)). Jun 1972. 20p. (In German). Dep. NTIS (U. S. Sales Only) $3.00.

A metal cryostat inserted in a superconducting magnet (50 mm bore) is described. It is used for studying superconductors in liquid helium below 4.2°K and in gas above 4.2°K. The temperature is kept constant at ±0.01°K by a temperature control device with an electrical heater. The sample is measurable at currents of up to several hundred amperes. (auth)

**23491** (IPP-4/100) INVESTIGATION OF CRYOGENIC STABILITY AND RELIABILITY OF OPERATION OF $Nb_3Sn$ COILS IN HELIUM GAS ENVIRONMENT. Martinelli, A. P.; Wipf, S. L. (Max Planck-Institut Fuer Plasmaphysik, Garching (West Germany)). Jul 1972. 11p. (CONF-720513-14). Dep. NTIS (U. S. Sales Only) $4.00.

From Applied superconductivity meeting; Annapolis, Maryland, USA (1 May 1972).

The optimum operating temperature of coils with regard to economy of refrigeration and price of superconductor is above 4.2°K. The performance of $Nb_3Sn$ coils made of 2, 4, and 8 pancakes (ID 22 cm, OD 32 cm, tape width 0.5 cm) was tested in the 4.2 to 17°K range. The cryogenic stability limit is calculated in liquid helium to be 90 A and is measured to be 70 A in gas at 4.2°K, dropping to about 20 A when T approaches $T_c$. Above these current limits, i.e., in the metastable range, the coils were tested for their response to local heating, which was applied in steady state (isothermal disturbance) or as a pulse (adiabatic disturbance) of increasing power until quench occurs. A model of the coil response to local heating is developed and compared with the experimental results. (auth)

**23492** (JINR-P8-6915) CURRENT-VOLTAGE CHARACTERISTICS OF POINT TUNNEL TRANSITION SUPERCONDUCTOR-NORMAL METAL SUPERCONDUCTOR. Vasiliev, B. V.; Simkin, V. G. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Neutron Physics). 1971. 10p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

Theoretical calculations of current–voltage characteristics of superconducting point contacts are presented and compared with experiment. (auth)

**23493** FLUX FLOW MEMORY SWITCH (ENGINEERING MATERIALS). (Cornell Univ., Ithaca, N. Y. Dept. of Materials Science and Engineering). (CAPE-2321).

A novel memory switch, based on the multiple-valued voltage–current (V–I) characteristic of a plastically deformed type-II superconductor, is described. The switch consists of a Nb single crystal, which had been prestrained 1% in tension. The V–I characteristic of this crystal in the mixed state depends markedly on the conditions under which the flux line lattice (FLL) is created. At 2.60 kOe, for example, V = 0 at I = 6.4A if the FLL has been previously formed by cooling from above $T_c$(H). If the current is subsequently raised into the flux flow regime, the structure and/or pinning of the FLL is "degraded" such that V = 2.9 μV at I = 6.4A. A 2 amp, 10m sec current pulse above a steady 6.4A current is sufficient to cause "degradation" and switching to the "on" state. Switching back to the "off" state (V = 0) may be accomplished by sending a current pulse sufficient to heat the crystal above $T_c$(H). (auth)

**23494** CRYOPUMPING. Hobson, J. P. (Univ. Laval, Quebec). J. Vac. Sci. Technol.; 10: No. 1, 73-79(1973).

A review is given of cryopumping. The flexibility, high available speed, and wide pressure range of this method of pumping are emphasized. Basic theory is presented, as well as modifications to the theory found in practical situations. Cryopumps are divided into two broad classes, cryosorption pumps and condensation pumps, depending on whether the surface coverage is less than or greater than about 5 monolayers, respectively. Five types of cryopumps, with examples, are distinguished: bare surface pumps, pumps with loose adsorbents, pumps with bonded adsorbents, pumps utilizing frozen deposits, and condensation pumps. (auth)

**23495** JOINING SUPERCONDUCTORS. Garrett, M. E.; Scott, J. P. (to British Oxygen Co. Ltd.). British Patent 1,298,068. 29 Nov 1972. Filed date 6 Mar 1969. 2p.

The method described aims at joining superconductors by a joint that retains the integrity of the superconductive path through the joint, and employs the process known as "cold welding" or "cold pressure welding," the materials being welded together by the application of pressure. The process may be carried out at ambient temperature, although a little heat may be advantageous; alternatively it may be carried out at or near temperatures at which the conductors are superconductive. Careful preparation of the surfaces to be joined is very important, and all contaminants and absorbed films must be removed. In the welding of stabilized superconductors the matrix material must be removed from the conductors to expose the filamentary superconductors. The joint may be formed by an applied transient force, such as caused by a blow or explosion, or by a continuously applied force produced by a manual or mechanical tool. Best results are obtained if the welding pressure is applied to the ends to be welded so as to cause them to shear during the welding operation; this leads to breaking up of any surface films. The joint is annealed locally at a suitable temperature and for a suitable time, for example, 425°C for 30 mins. for a Nb/Ti alloy, to relieve strain. It is desirable in the case of stabilized superconductors to position a material, such as Cu, around the welds so as to stabilize the superconductors along their whole length. (UK)

**23496** CURRENT LEADS FOR 4.2 K CRYOSTATS. Claudet, G.; Senet, L. (CEN, Grenoble, France). Cryogenics; 13: No. 1, 44-46(Jan 1973).

Two sets of current leads for a 4.2°K cryostat, of 200 and 800 A capacity respectively, were investigated for heat losses. Heat losses were measured under various conditions of helium level and various current values and are summarized. It is concluded that low heat losses, near 1 mW $A^{-1}$, not very far from ideal values, can be realized without using very pure materials or sophisticated systems when considering heat exchange conditions between gas and leads. The large influence of the part of the current leads just above helium level was demonstrated and the work of previous authors who recommend the use of superconductors in this region is agreed. (UK)

**23497** DEVELOPMENT AND USE OF LABORATORY SUPERCONDUCTING SOLENOIDS WITH FIELDS UP TO 119 kOe. Lazarev, B. G.; Lazareva, L. S.; Golik, V. R.; Goridov, S. I. (Physical Technical Inst., Kharkov). Izv. Akad. Nauk SSSR, Ser. Fiz.; 36: No. 11, 2475-2478(Nov 1972). (In Russian).

The design and utilization of a large series of superconducting laboratory-type solenoids which could attain up to 119 kilo-oersteds of field are discussed. The solenoids were fabricated from superconducting wire from deformed Nb alloys. The operating volume of field of adequate homogeneity amounted to from 2 cm$^3$ to 500 cm$^3$ for solenoids with fields of 115 to 51 k-e. The use of ferromagnetic concentrators achieved a field of 161 k-e within a volume of ~10 mm$^3$. The solenoid field may be used at temperatures from that of liquid He to room temperature. (tr-auth)

**23498** SUPERCONDUCTIVE MAGNET WITH A HOMOGENEOUS MAGNETIC FIELD. Cesnak, L.; Kokavec, J.; Rybar, A. Elektrotech. Cas.; 23: No. 7, 402-412(1972). (In Slovak).

A method is described for the design of a superconductive magnet with a very homogeneous magnetic field, by the aid of which a magnet with a maximum relative induction deviation on the axis of $10^{-2}$ on an intercept of ±35 mm was designed and produced. Further a method is given for the measurement of relative magnetic field induction deviations from the chosen value by the aid of a Hall probe in connection with a Thomson bridge, by which deviations of the order of $10^{-5}$ can be recognized. (auth)

**23499** USE OF LARGE SUPERCONDUCTING MAGNETS IN RESEARCH AND INDUSTRY. Komarek, P. (Kernforschungsanlage, Juelich, Ger.). Acta Phys. Austr.; 35: No. 3, 232-248(1972). (In Germany).

Based on solid state physics, an attempt is made to outline the present technology of large superconducting magnets. As determining factor appears the stabilizing problem of superconducting wire which, thus far, is solved satisfactorily only for Nb–Ti combinations. At fields above 100 kG, only $Nb_3Sn$ or $V_3Ga$ are suitable as superconducting materials. For these, however, the stabilizing problem is still unsolved and no large magnets are available for this field range which claims strong interest in future applications. Recent practical experience springs from large magnets for nuclear- and high-energy physics as well as from the more complicated systems for MHD generators. In these areas, technical and economic developments will lead to large-scale application in the future. From a long term view, superconducting magnets are most important in future fusion reactors. By means of the Tokamak reactor, the requirements are outlined. In addition to multiple large direct current magnets of solenoid-like configuration with field strengths exceeding 110 kG, requirements also include a large pulsed coil for plasma heating. (tr-auth)

# PHYSICS (NUCLEAR)

## Neutron Interactions with Matter

*Refer also to abstract 23766.*

**23500** (AD-743171) MORSE CODE WITH COMBINATORIAL GEOMETRY. Topical Report, January 1, 1971–February 28, 1972 1972. Straker, E. A.; Scott, W. H. Jr.; Byrn, N. R. (Science Applications, Inc., La Jolla, Calif. (USA)). May 1972. Contract DASA01-71-C-C-0044. 173p. (SAI–72–511–LJ). NTIS.

The combinatorial geometry allows efficient Monte Carlo radiation transport calculations of detailed three-dimensional geometries. Because regions and media are formed by combination of basic bodies such as boxes, spheres, cylinders, and others, the input required of the user is both relatively simple and easily modified. The MORSE code is a multigroup neutron and gamma ray transport Monte Carlo code that may solve either neutron, gamma ray, or coupled neutron–gamma ray problems in either the forward and adjoint mode. MORSE has a wide variety of available input options, including splitting, Russian roulette, exponential transform, energy biasing, importance regions, albedo surfaces, and the scoring options available in the SAMBO analysis package. This document details the incorporation of a new version of combinatorial geometry into the MORSE code and is meant as a user's manual. (auth) (GRA)

**23501** (COO-3058-32) ITERATED SEQUENTIAL TRANSPORT APPROXIMATION FOR ANISOTROPIC SPECTRAL MOMENTS. Gibbs, D. C.; Becker, M.; Malaviya, B. K. (Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Nuclear Science). [nd]. Contract AT(11-1)-3058. 8p. Dep. NTIS.

An improved procedure for generating anisotropic weighting spectra is derived. This procedure leads to differences from previous methods in the presence of strong resonance structure. (1 table) (auth)

**23502** (IAE-2143) PROGRAM FOR CALCULATING THERMAL UTILIZATION OF NEUTRONS IN MULTIREGION CYLINDRICAL CELL 3 (PRAKTINETS 3). Part 1. Characteristics of the Program, Rules of the Program Using, and Report About the Program Testing. Sultanov, N. V. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Atomnoi Energii). 1971. 19p. (In Russian). INIS.

A brief resume of the program PRAKTINETS 3 is given. The input into the program of the initial data and the output of intermediate values are described in addition to the final characteristics of the multiregion cylindrical cell 3. A sample of input and output information for the program is furnished. A numerical calculation was performed on a computer to illustrate the influence of the tolerances $G_1$ and $G_2$. The latter are approximations for the values of the mean neutron fluxes in the zone and the coefficient of thermal utilization of neutrons. (tr-auth)

**23503** (KFKI-72-64) SOPHIE AND CECILY: TWO CODES FOR CALCULATING SPACE DEPENDENT FAST NEUTRON SPECTRA. Gado, J.; Szatmary, Z. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). 1972. 51p. Dep. NTIS (U. S. Sales Only).

The codes SOPHIE and CECILY are generalized versions of the asymptotic slowing down code GRACE. Both codes are used for the calculation of the slowing down neutron spectrum in one-dimensional (slab, cylindrical, spherical) geometries. The code SOPHIE is a criticality code, while CECILY solves the space-dependent slowing down problem within the elementary cell of the infinite fuel lattice. All three codes need the file called REACTOR TAPE, containing the nuclear data. (auth)

**23504** (MRR-99) COMPARATIVE CALCULATIONS BETWEEN EXPLICIT AND IMPLICIT DIFFERENCE APPROXIMATIONS OF THE SPACE AND TIME DEPENDENT MULTIGROUP NEUTRON DIFFUSION EQUATION. Werner, W. (Technische Universitaet, Munich (West Germany)). Jan 1972. 17p. (In German). INIS.

Comparative calculations were performed between different methods for the difference approximation of the space- and time-dependent neutron diffusion equation, namely the explicit program TRANSFLUX (Du Fort Frankel type), the implicit program COSTANZA (solution of linear systems by relaxation technique), and the fully implicit ADI program DYNFUX. For a 2-dimensional excursion problem, the computing times needed to achieve prescribed accuracy were determined for the 3 programs. Shortest run times were obtained with DYNFUX, followed by TRANSFLUX, and COSTANZA. (GF)

**23505** (RT/FI–(72)31) CONVERGENCE OF THE INTEGRAL TRANSFORM METHOD FOR THE SOLUTION OF THE MONOENERGETIC NEUTRON TRANSPORT EQUATION. Boffi, V. C.; Molinari, V. G.; Premuda, F.; Trombetti, T. (Comitato Nazionale Per L'Energia Nucleare, Rome (Italy)). 2 Aug 1972. 23p. (CONF-700578–1). Dep. NTIS (U. S. Sales Only).

Results concerning the convergence problem raised by the replacement of the kernel of the Fourier-transformed integral neutron transport equation with a sequence of degenerate kernels are presented. The practical implications of the rapidity of convergence are discussed in the light of some numerical results. (5 figures, 1 table) (auth)

**23506** SYSTEM OF SINGULAR INTEGRAL EQUATIONS IN THE THEORY OF STATIONARY PLANE TRANSPORT MONOENERGETIC NEUTRONS. II. Draganu, M. Bull. Math.; 14: No. 3, 293-306(1970). (In French).

The study related to the extension of Papmehl's method to the problem of unidimensional transport of monoenergetic neutrons in the case of a semiplane admitting a diffusion with linear anisotropy is continued. The system of two singular integral equations which governs monoenergetic neutron transport in the case of a semiplane and of a linear anisotropic diffusion law is solved. Equations are obtained which generalize for the case of a linear anisotropic diffusion Papmehl's formulae connected with the study of the monoenergetic neutron transport problem in a semiplane, presuming an isotropic diffusion. (Rom. Sci. Abstr.)

**23507** SYSTEM OF SINGULAR INTEGRAL EQUATIONS IN THE THEORY OF STATIONARY PLANE TRANSPORT MONOENERGETIC NEUTRONS. I. Draganu, M. Bull. Math.; 14: No. 2, 153-169(1970). (In French).

An attempt is made to extend Papmehl's method to the problems of unidimensional transport of monoenergetic neutrons in the case of a semiplane assuming a linear anisotropic diffusion, and to give a diffusion law of a more general type. Papmehl's method is applied to the problem of unidimensional transport of two groups of neutrons in case of a semiplane not only as an isotropic diffusion but also in an anisotropic law of a general form. Some considerations are developed, related to the solution of the stability equations in some particular cases by the methods of the systems theory of singular equations with Cauchy nuclei. (Rom. Sci. Abstr.)

**23508** HALF–RANGE COMPLETENESS IN MULTIGROUP TRANSPORT THEORY. Pahor, S.; Suhadolc, A. (Univ. of Ljubljana, Yugoslavia). Transp. Theory Statist. Phys.; 2: No. 4, 335-345(1972).

The half-range completeness of vector eigenfunctions of the multigroup transport equation with isotropic scattering is derived by applying full-range completeness to the solution of a half-space albedo problem. (auth)

**23509** MATRIX-INVERSION SOLUTION TO THE DISCRETE ORDINATE EQUATIONS FOR NEUTRON TRANSPORT. Mays, C. W. Charlottesville, VA; Univ. of Virginia (1972). 150p. University Microfilms Order No. 72-33,245.

Thesis (Ph. D.).

The discrete-ordinate equations are customarily solved for the in-group fluxes by iterative techniques. A method is developed whereby the discrete-ordinate equations for slab geometry are transformed to a set of equations that are stable and can, therefore, be solved numerically by a noniterative calculation for each energy group. This system of linear algebraic equations is solved at each space mesh point by matrix inversion. The distinguishing feature of this method over other matrix inversion methods is that the scattering source terms are treated as general anisotropic for both in-group and group-to-group scattering. Agreement between this method and the iterative method for critical eigenvalue calculations is excellent. The calculational time required for the matrix inversion method is generally less than it is for the iterative method. Scaling techniques employed by iterative methods to accelerate convergence and assure neutron conservation can present problems; since the matrix inversion method does not require scaling, it is superior in this respect. The matrix inversion method provides exact results for each group. (Diss. Abstr. Int., B)

**23510** PARTIAL-RANGE LEGENDRE POLYNOMIAL SOLUTION OF THE NEUTRON-TRANSPORT EQUATION. Garland,

W. J.; Harms, A. A. (McMaster Univ., Hamilton, Ont.). Transp. Theory Statist. Phys.; 2: No. 4, 347-364(1972).

A new variant of the spherical harmonics formalism is used in solving the one-speed neutron-transport equation. One unique facet of this formalism is the imposition of arbitrary angular segmentations that can be chosen to maximize the computational accuracy in a given modal–nodal approximation. It is found that this solution procedure permits the exact calculation of some neutron-transport parameters using a low-order expansion. (auth)

**23511** COMPLETE-BACKSCATTERING EFFECTS IN NEUTRON WAVE PROPAGATION PROBLEM. Goyal, I. C.; Ghatak, A. K.; Singh, O. P.; Sobhana, S. (Indian Inst. of Tech., New Delhi). Transp. Theory Statist. Phys.; 2: No. 4, 321-333(1972).

Using the Fourier transform technique, the neutron-wave-propagation problem was studied in the presence of complete backscattering plus isotropic scattering of neutrons. The discrete and continuum solutions were obtained in one-speed transport theory as well as in multi-velocity transport theory. A one-term degenerate kernel was used for carrying out the analysis. (auth)

**23512** TIME EIGENVALUES OF THE NEUTRON-TRANSPORT EQUATION FOR FAST, SUBCRITICAL ASSEMBLIES. Adalioglu, U. (Cekmece Nuclear Research Center, Istanbul); Duderstadt, J. J. Transp. Theory Statist. Phys.; 2: No. 4, 275-294(1972).

The time decay constants characterizing the time behavior of a neutron pulse in a subcritical fast assembly are investigated by analyzing the time-eigenvalue spectrum of the transport operator for fast neutrons. To simplify this analysis, isotropic scattering was assumed, and a simple model of inelastic scattering was employed. By applying the techniques of functional analysis familiar from the study of the time-eigenvalue problem for thermal neutrons, it has been possible to classify the spectrum of the transport operator into the usual band spectrum for $\mathrm{Re}\{s\} \leq -\lambda^*$, where $\lambda^*$ is the minimum collision frequency, and a point spectrum in the region $\mathrm{Re}\{s\} > -\lambda^*$. It was demonstrated that this point spectrum was void for either sufficiently small assembly sizes or sufficiently small concentrations of fissile material. (auth)

**23513** NEUTRON FLUX IN POLYGONAL CELLS. Takeda, T.; Sekiya, T. Technol. Rep. Osaka Univ.; 22: 345-358(Oct 1972).

Neutron flux distributions in polygonal cells are calculated by the multiple collision method. The method is extended to multiregion cell problems by adopting the balance equations among neutron currents on boundaries of each annular region and by obtaining the multiple collision probability through a variational technique. This corresponds to an improvement of the usual calculation of the multiple collision probability by the flat flux approximation. At the outermost moderator region the concept of the extended Dancoff factor is used, which makes it possible to treat various types of lattice array. (auth)

**23514** SPACE AND ANGLE DEPENDENT COLLISION PROBABILITY IN CELL PROBLEMS. Takeda, T.; Sekeya, T. (Osaka Univ., Suita, Japan). J. Nucl. Energy; 27: No. 1, 15-24(Jan 1973).

The integral transport equation is formulated in terms of the generalized collision probability in a cylindrical lattice cell in one velocity. The anisotropy of the neutron angular distribution and the scattering is considered by representing them with spherical harmonics series respectively. The space dependence of the neutron distribution is taken into account by representing it with a Legendre series in each annular region. The isotropic return condition or white boundary condition is adopted for the generalized collision probability. One group disadvantage factors are calculated for cylindrical lattices in both cases of isotropic and linearly anisotropic scattering using the generalized first-flight collision probability. (auth)

**23515** PROPAGATION IN SPACE AND ANGLE OF NEUTRON FLUX DISCONTINUITIES. 1. Elastic Scattering. Beynon, T. D.; Weaver, D. R. (Univ. of Birmingham, Eng.). J. Nucl. Energy; 27: No. 1, 25-37(Jan 1973).

Exact expressions are derived for the propagation in space and angle of the Placzek-type discontinuities in a neutron field. For elastic scattering it is shown that, with a plane isotropic source, the discontinuities in the flux and current of neutrons may be significant up to 2 and 3 mean free paths from the source. Comparisons are made of the exact solutions with those obtained assuming isotropic and linearly anisotropic scattering. (auth)

## Nuclear Properties and Reactions, $A \leq 5$

*Refer also to abstracts 23524, 23526, and 23797.*

**23516** (LYCEN-7265) COHERENT SURVEY OF SOME NUCLEAR PROPERTIES GIVEN BY A NON-LOCAL SEPARABLE NUCLEON-NUCLEON INTERACTION. El Baz, E.; Fayard, C.; Lamot, G. H.; Meyer, J.; Nahabetian, R. S.; Pigeon, J.; Boschan, P. (Lyon Univ. (France). Institut de Physique Nucleaire). Oct 1972. 30p. Dep. NTIS (U. S. Sales Only).

A set of nonlocal parameters was determined for a Mongan (case IV) separable nucleon–nucleon interaction. The M-5 potential defined in this way is shown to provide a correct description of two-nucleon elastic scattering below 400 MeV, deuteron binding energies and quadrupole moments, scattering lengths, effective-range low-energy parameters, triton binding energy in a coupled three-body treatment, saturation of infinite nuclear matter, binding energy of some spherical nuclei, and the Hartree–Fock model for even–even nuclei in the 2s-1d shell. (FR)

**23517** AMADO MODEL AND THE ANGULAR DEPENDENCE OF QUASIFREE SCATTERING IN THE $^{2}$H(p,2p)n REACTION. Anzelon, G. (Univ. of California, Los Angeles); Slaus, I.; Margaziotis, D. J.; Epstein, M. B. Nucl. Phys.; A202: No. 3, 593-601(1973).

Quasifree scattering in the $^{2}$H(p,2p)n reaction has been studied at 30.3 MeV. The data are compared with the Amado model. The model fits individual spectra and reproduces the general trend of angular distributions. However, a few discrepancies as large as 60% are found, for which possible explanations are given. (auth)

**23518** ELASTIC SCATTERING OF NEUTRONS BY PROTONS AND DEUTERONS AND THE $^{2}$H(n,p)2n REACTION IN THE 20 TO 30 MeV RANGE. Burrows, T. W. Madison, WI; Univ. of Wisconsin (1972). 100p. University Microfilms Order No. 72-24,874.

Thesis (Ph. D.).

The relative angular distributions for elastic n–p scattering were studied between 71.2 and 161° (cm) for neutron energies of 24.0, 26.0, 27.2, and 29.2 MeV. The angular distributions for elastic n–d scattering were measured between 90 and 166° (cm) for neutron energies of 24.0 and 27.2 MeV. The neutron cross section at the minima is progressively lower than that at the p–d minima as the incident energy increases. The emission proton spectra from the $^{2}$H(n,p)2n reaction were studied at emission angles of 11 and 22° (lab) for incident neutron energies of 24.0 and 27.2 MeV. In addition, the emission proton angular distributions between 11 and 46° (lab) were measured. (RWR)

**23519** SOME APPLICATIONS OF BRUECKNER THEORY TO LIGHT NUCLEI. Wilson, M. R. Lawrence, KS; Univ. of Kansas (1972). 165p. University Microfilms Order No. 72-32,949.

Thesis (Ph. D.).

By employing primarily the Reid potentials (with emphasis on the soft-core interaction), first order Brueckner binding energies are calculated for $^{2}$H, the trinucleon system, $^{4}$He, $^{16}$O, and $^{40}$Ca. G-matrix elements are obtained by a free-particle reference-spectrum method in which Pauli corrections are performed in a two-body oscillator representation. Convergence of the calculations is investigated. Except for the deuteron, all of the model nuclei are seriously underbound. Compared to the hard-core interaction, Reid's soft-core potential gives somewhat (~1 MeV/A for $^{16}$O) more binding and yields better radii and single-particle energies. Calculated triton binding energies are all in excellent agreement with results of more elaborate variational calculations. A first-order (in G) Bloch–Horowitz calculation is done for $^{6}$Li. Overlaps of nonorthogonal self-consistent model wave functions are calculated. The calculated spectra have only a weak energy dependence. (Diss. Abstr. Int., B)

**23520** PHOTODISINTEGRATION OF $^{3}$He AT ENERGIES BETWEEN 200 AND 600 MeV. McDonald, K. T. Pasadena, CA; California Inst. of Tech. (1972). 193p. University Microfilms Order No. 72-30,818.

Thesis (Ph.D.).

Differential cross sections for the two-body photodisintegration of $^{3}$He, $\gamma + {}^{3}\mathrm{He} \rightarrow p + d$, were measured between incident photon energies of 200 and 600 MeV, and for center-of-mass angles between 30° and 150°. Both final-state particles were detected in arrays of wire spark chambers and scintillation counters; the high-momentum particle was analyzed in a magnet spectrometer. The results are interpreted in terms of amplitudes to produce the $\Delta(1236)$ resonance in an intermediate state, as well as nonresonant amplitudes. (Diss. Abstr. Int., B)

## Nuclear Properties and Reactions, $6 \leq A \leq 19$

*Refer also to abstracts 23516, 23519, 23540, 23610, and 23623.*

**23521** (JINR-E4-6895) DECAY OF THE PHOTO RESONANCE IN $^{14}$N AND $^{14}$C NUCLEI. Eramzhyan, R. A.; Jaeger, H. U.; Kissener, H. R. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1973. 26p. Dep. NTIS (U. S. Sales Only).

The decay of the photoresonances in $^{14}$N and $^{14}$C nuclei is analyzed in terms of the shell model with intermediate coupling. Cross sections and branching ratios of nucleon channels are compared with experimental data. Successive decay branches are estimated. (9 figures, 4 tables) (auth)

**23522** (JINR-P1-6835) STUDY OF THE ($\pi^+$, 2p) REACTION ON Li NUCLEI AT THE ENERGY E = 85 ± 4 MeV. Nadezhdin, V. S.; Petrov, N. I.; Satarov, V. I.; Vzorov, I. K. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1972. 25p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.25.

The differential cross sections, the sum energy spectra and the distributions of the events over residual nucleus momenta were measured for the reaction ($\pi^+$, 2p) on $^6$Li and $^7$Li nuclei at the energy E = 85 ± 4 MeV. In case of $^6$Li nucleus the measurements were performed for six sets of the angle pairs characterizing the proton detector location with respect to the $\pi^+$-meson beam; in the case of $^7$Li nucleus it was made for three sets. The obtained data are compared with the theoretical predictions. It is shown that the cross sections of $\pi^+$-meson capture by nuclear quasideuterons are greater than the corresponding values for free deuterons. (auth)

**23523** (TID-26290) HEAVY-ION SCATTERING IN THE MASS-16 REGION. Malmin, R. E. (Argonne National Lab., Ill). June 1972. Contract W-31-109-eng-38. 172p. Dep. NTIS $10.75.

The observation of pronounced gross structure in the $^{16}$O + $^{16}$O elastic scattering excitation function data has led to much theoretical and experimental interest in the heavy-ion-nucleus interaction. It was attempted to extend the range of heavy-ion systems upon which extensive, high-quality data exist; to look for systematic trends; and to ascertain whether the systematics of the scattering of complex nuclei in the mass-16 region can be described by a complex potential whose parameters vary smoothly with energy and target mass. Excitation functions were measured for the $^{16}$O + $^{14}$N and $^{16}$O + $^{15}$N systems at center-of-mass angles from 70 to 100° and over an energy range of 20 to 60 MeV (lab) in 0.5 MeV steps. In addition, excitation function data were obtained for the $^{12}$C + $^{16}$O system over the above energy range but in 250-keV steps and at center-of-mass angles of 40 to 160° in 10° intervals. This system was selected for study because it also afforded an opportunity to test extended optical models which include the effects of l-dependent absorption and elastic transfer. Angular distribution data for the $^{12}$C + $^{16}$O system were measured at 11 energies from 27 to 53 MeV and covered an angular range of 20 to 140° (cm). All three of these systems exhibited diffraction-like excitation- function structure similar to, although not so pronounced as, that seen in the $^{16}$O + $^{16}$O system. In addition, the $^{12}$C + $^{16}$O system displayed a large amount of compound elastic fluctuations and very large back-angle cross sections (20 mb/sr at 160°). A statistical-model analysis indicated a correlation width of ~115 keV. The percentage direct interaction, $y_D$, extracted from this analysis implies that less than 15% of the large cross sections observed at back angles is attributable to compound elastic scattering. An optical-model analysis of these systems using data at angles $\theta_{cm} \lesssim 100°$ yielded a real potential which was shallow, in agreement with the original $^{16}$O + $^{16}$O potential and with the theoretical calculations of a number of authors. The depth of the potential, however, increased with energy. The empirically determined energy dependence was larger in magnitude and opposite in sign from that found in nucleon scattering, and was in fairly good agreement with the calculations of Fliessbach. This same energy-dependent potential also described a large number of other systems in the mass-16 region. This potential was not successful, however, in describing the very large cross sections in the back-angle $^{12}$C + $^{16}$O data. Both the elastic transfer model and the l-dependent absorption model yielded improved fits to these data; and while the analysis tended to prefer an explanation in terms of angular momentum-dependent absorption, the elastic transfer model cannot be ruled out on the basis of these data alone. Finally, a sharp resonance was observed in the $^{12}$C + $^{16}$O system at $E_{cm}$ = 19.7 MeV, corresponding to an excitation of 36.5 MeV in the $^{28}$Si compound system. Inelastic scattering excitation functions leaving $^{16}$O in the unresolved $0^+$, $3^-$ states at 6.1 MeV are correlated with the elastic channel, while the $2^+$ state at 4.43 MeV in $^{12}$C is not. The width of the resonance (~400 keV) was wider than that of the underlying compound nuclear states but probably too narrow to be a shape resonance. An analysis of angular distribution data on-resonance indicated a spin of I = 14. (74 figures, 2 tables, 111 references) (auth)

**23524** (UCRL-50400(Vol.12)) INTEGRATED SYSTEM FOR PRODUCTION OF NEUTRONICS AND PHOTONICS CALCULATIONAL CONSTANTS. Volume 12. An Atlas of Resolved Neutron Resonance Parameters. Perkins, S. T.; Gyulassy, M. (California Univ., Livermore. Lawrence Livermore Lab.). 1 Jul 1972. Contract W-7405-Eng-48. 1372p. Dep. NTIS.

The LLL Experimental Neutron Cross Section Library included 51,000 resolved resonance parameters as of May 1, 1972. This report contains a selected set of parameters obtained from that compilation. (auth)

**23525** (UCRL-50400(Vol.13)) AN INTEGRATED SYSTEM FOR PRODUCTION OF NEUTRONICS AND PHOTONICS CALCULATIONAL CONSTANTS. Volume 13. An Atlas of Unresolved Neutron Resonance Parameters. Gyulassy, M.; Perkins, S. T. (California Univ., Livermore. Lawrence Livermore Lab.). 1 Sep 1972. Contract W-7405-eng-48. 727p. Dep. NTIS $38.50.

A set of resolved resonance parameters was selected from the 51,000 experimental parameters that were in the Lawrence Livermore Laboratory Experimental Neutron Cross Section Library as of May 1, 1972. This report contains the unresolved parameters that were generated from that selected set. (auth)

**23526** (UCRL-51310(Add.)) SPECTRA OF NEUTRONS FROM DEUTERON BOMBARDMENT OF LIGHT NUCLEI. Weaver, K. A. (California Univ., Livermore. Lawrence Livermore Lab.). 26 Jan 1973. Contract W-7405-Eng-48. 169p. Dep. NTIS.

Spectra of neutrons produced in the bombardment of light nuclei by deuterons were measured in order to investigate the usefulness of the reactions as high-intensity neutron sources. Neutrons emitted at angles up to 32° were studied for thin targets of deuterium and beryllium and for thick targets of lithium, beryllium, and carbon for bombarding energies up to 20 MeV. (auth)

**23527** STUDY OF ENHANCED BACKWARD $\alpha$-SCATTERING ON NUCLEI WITH A = 12 to 18. Oeschler, H.; Fuchs, H.; Schroeter, H. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Nucl. Phys.; A202: No. 3, 513-529(1973).

Angular distributions of the elastic $\alpha$-scattering $^{12}$C, $^{14}$C, $^{15}$N, $^{16}$O and $^{18}$O at energies between 22 and 29 MeV and excitation functions on $^{14}$C have been measured. The cross sections at large angles for all isotopes except $^{18}$O are enhanced by two orders of magnitude over the pure Coulomb scattering. These phenomena are interpreted as due to sequences of resonances with parameters depending smoothly on the l-value. The Regge formalism describing such resonances was applied. By adding one Regge pole to the scattering matrix of the optical model a much improved description of the data could be obtained. The extracted resonance parameters suggest that they are intermediate-structure resonances. The strength of the backward enhancement may be correlated with the total width which reflects coupling to the states of the compound-nucleus system. The relation of our interpretation to other resonance descriptions is discussed. (auth)

**23528** MAGNETIC SUBSTATE POPULATION CROSS-SECTIONS IN INELASTIC ALPHA-NUCLEUS SCATTERING. Glanz, P. K. Storrs, CT; Univ. of Connecticut (1972). 88p. University Microfilms Order No. 72-32,316.

Thesis (Ph. D.).

Inelastic alpha-nucleus collisions which lead to a nuclear excitation with spin I are considered. The inelastic cross section for which the projection of I along the normal to the scattering plane is M is called $\sigma_M(\Theta)$. The sensitivity of the various $\sigma_M$'s to the assumptions of the optical-model parameters and to the imaginary part of the inelastic transition potential is investigated. A collective deformed model is assumed for the inelastic transition potential, and most of the calculations are carried out in DWBA. The value of I is taken equal to 2, with $^{40}$Ca and $^{12}$C considered as target nuclei. Some coupled-channels calculations are also carried out in order to explore the effect of nuclear reorientation on the $\sigma_M$'s. The result is compared with a DWBA calculation which has an $\bar{L}\cdot\bar{I}$ (spin-orbit) potential in the exit channel. The main usefulness of the measurement of the $\sigma_M$'s appears to be in the determination of the imaginary parts of the elastic optical potentials and of the inelastic transition potential, particularly if the interference with the Coulomb excitation mechanism is also considered. (Diss. Abstr. Int., B)

**23529** STUDY OF THE $^{12}$C(p,$^3$He)$^{10}$B REACTION AT 185 MeV USING A SPARK CHAMBER DETECTOR. Dahlgren, S.; Johansson, A.; Renberg, P. U.; Tibell, G. (Univ. of Uppsala). Phys. Scr.; 6: No. 1, 5-10(1972).

Differential cross sections for the reaction $^{12}$C(p,$^3$He)$^{10}$B at 185 MeV were measured in the angular region 4 to 20°. The momentum analysis of the $^3$He particles was performed in a magnetic spectrometer. A spark chamber with current distribution read-out was used as a detector, and it was triggered by pulses from a scintillation telescope. An overall energy resolution of about 350 keV was obtained in the energy spectra. The angular distributions of the cross section were all peaked in the forward direction. (auth)

**23530** RELATIVE INTENSITIES AND ANGULAR DISTRIBUTIONS OF GAMMA RAYS FROM THE NUCLEAR REACTION $^{19}F(p,\alpha\gamma)^{16}O$. Hellborg, R.; Ask, L. (Univ. of Lund, Sweden). Phys. Scr.; 6: No. 1, 47-54(1972).

The relative intensities of the 6.13, 6.92, and 7.12 MeV gamma rays from the nuclear reaction $^{19}F(p,\alpha\gamma)^{16}O$ have been measured for proton energies between 1.3 MeV and 2.2 MeV, in steps of about 6 keV. In addition, angular distributions of gamma rays have been measured on and around the different resonances for 22 proton energies in the energy interval. A lithium-drifted germanium detector with an energy resolution of about 0.5% has been used; this permitted the two 7 MeV components to be fully resolved. The behavior of the three components at the various resonances differ somewhat. (auth)

**23531** CLUSTER MODEL AND $^{12}C$ NUCLEUS STRUCTURE. Vashakidze, I. Sh.; Dzhalaganiya, T. R. (Tbilisi State Univ., USSR). Yadern. Fiz.; 16: No. 5, 941-945(1972). (In Russian).

With the view to study the ground and excited states of $^{12}C$ nucleus use is made of the $\alpha$-particle model. As one particle wave functions there are taken the functions, dependent of three radius-vectors $R_j$, which fix the center of three $\alpha$-particles with respect to arbitrary coordinate system. The wave functions describe motion of four nucleons with respect to the aforementioned centers. The nucleus total wave function is constructed with account for Pauli principle. It has a maximum symmetry in the sense of Wigner supermultiplet theory, i.e., [444] symmetry. The basic triangle configuration, when $\alpha$-particle centers are in the vertices of an equilateral triangle, is studied alongside with the linear one, when $\alpha$-particle centers are situated along the straight line. Real nucleon-nucleon interactions are used in calculations. The wave functions are projected into the functions with a definite moment. (auth)

**23532** ANGULAR DISTRIBUTIONS AND EXCITATION FUNCTIONS OF $(^{15}N,^{16}N)$, $(^{14}N,^{16}N)$, $(^{15}N,^{17}N)$, $(^{14}N,^{17}N)$ REACTIONS. Artyukh, A. G.; Volkov, V. V.; Pomorski, L.; Tys, Ya. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 16: No. 5, 905-910(1972). (In Russian).

The angular distributions and excitation functions for the reactions of picking up one, two or three neutrons when irradiating nucleus by $^{14}N$ and $^{15}N$ ions have been measured. The surface character of the investigated reactions has been established. The dependence of the reaction cross section on the neutron binding energy in the donor nucleus has been obtained. (auth)

**23533** PROTON-INDUCED REACTIONS IN THE STUDY OF NUCLEAR PROPERTIES. Renberg, P. U. Acta Universitatis Upsaliensis, No. 226. Uppsala; Uppsala Univ. (1972). 16p. Thesis.

The work underlying this thesis contains experimental results from studies of various types of nuclear reactions performed with protons at energies from 179 to 600 MeV. Some of the data were treated in the shell model of the nucleus with the use of the optical model and the impulse approximation. This publication contains only a brief summary of the work. The complete results are contained in eleven papers, which have already appeared in the open literature. (RWR)

**23534** $^{16}O(p,p\alpha)^{12}C$ REACTION AT PROTON ENERGY 50 MeV. Boikov, V. V.; Vel'berg, B. V.; Poshchakov, I. I.; Ostroumov, V. I. (Leningrad Polytechnic Inst.). Yadern. Fiz.; 16: No. 5, 901-904 (1972). (In Russian).

Under conditions of full geometry the mechanism of $^{16}O(p,p\alpha)^{12}C$ reaction has been studied by a photoemulsion method for proton energy 50 MeV. The integral cross-section for the reaction has been obtained. Some information on probabilities of residual $^{12}C$ nucleus production in the basic and first excited states is presented. A conclusion on dominating role of two stage processes with $^{16*}O$ and $^{13*}N$ intermediate nucleus production is made. The ratio between these channels is estimated to be 1.5 : 1. Momentum and angular distributions of $^{12}C$ residual nuclei are reported. (auth)

**23535** NEUTRINO EXCITATION OF NUCLEAR LEVELS IN $^{12}C$. Ueberall, H. (Catholic Univ. of America, Washington, DC); Lambers, B. A.; Langworthy, J. B.; Kelly, F. J. pp 139-145 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

The results of a calculation are presented which predict the neutrino excitation of the T = 1 levels of $^{12}C$, via the reaction $\nu + {}^{12}C \rightarrow {}^{12}N^* + l^-$, where $l = e$ or $\mu$. (WDM)

## Nuclear Properties and Reactions, $20 \leq A \leq 38$

*Refer also to abstracts 22272, 23516, 23524, 23525, 23532, 23549, and 23610.*

**23536** ENERGY LEVELS IN $^{30}Si$ FROM THE $^{29}Si(d,p)^{30}Si$ REACTION. Mackh, H. (Max-Planck-Institut fuer Kernphysik, Heidelberg); Oeschler, H.; Wagner, G. J.; Dehnhard, D.; Ohnuma, H. Nucl. Phys.; A202: No. 3, 497-512(1973).

Energy levels in $^{30}Si$ up to 9.6 MeV have been studied with the $^{29}Si(d,p)^{30}Si$ reaction at incident energies of 11.5 MeV, 16 MeV and 20 MeV. The protons were recorded with the aid of magnetic spectrographs of the Browne–Buechner type and the Enge split-pole type. A previously unreported level was found at 7637 ± 10 keV. New spin and parity assignments and spectroscopic factors were obtained. The dominant features of the proton spectrum are interpreted within a simple two-particle model with an inert $^{28}Si$ core; e.g., evidence for $(2s_{1/2}\text{-}1f_{7/2})$ and $(2s_{1/2}\text{-}2p_{3/2})$ doublets in $^{30}Si$ was derived from the strong excitation of the $J^{\pi} = 3^-$ (5.49 MeV) and $4^-$ (6.50 MeV) states, and the $1^-$ (6.75 MeV) and $(2)^-$ (7.51 MeV) states, respectively. (auth)

**23537** NUCLEAR LIFETIMES IN $^{37}Ar$. Kruzek, R. G.; Chenevert, G. M.; Leighton, H. G.; Kern, B. D. (Univ. of Kentucky, Lexington). Nucl. Phys.; A202: No. 3, 530-534(1973).

The nuclear lifetimes of ten levels of $^{37}Ar$ with energies from 1.41 to 3.61 MeV have been measured by the attenuated Doppler-shift method using the $^{37}Cl(p,n\gamma)^{37}Ar$ reaction. (auth)

**23538** SEARCH FOR THE EXCITATION OF THE GIANT DIPOLE STATE BY DIRECT INELASTIC $^{3}He$ SCATTERING. Peterson, R. J. (Univ. of Colorado, Boulder). Nucl. Phys.; A202: No. 3, 557-560(1973).

The direct inelastic scattering of 41 MeV $^{3}He$ ions was studied for nuclear excitations in the vicinity of the giant dipole resonance (around 20 MeV). The targets studied were $^{24}Mg$, $^{26}Mg$, $^{50}Cr$, $^{60}Ni$ and $^{90}Zr$. An upper limit of only several $\mu b/sr$ was placed on the differential cross sections—lower than the yield observed for 182 MeV protons by a factor of $10^3$. By the use of DWBA calculation, this striking decrease was ascribed to the strong nuclear absorption of the $^{3}He$ projectiles. (auth)

**23539** ISOBARIC ANALOGUE STATES IN $^{28}Si$ FROM $(p,\gamma)$ REACTION IN $^{27}Al$. Ahmed, N. (Atomic Energy Centre, Dacca, Pakistan); Rahman, M. A.; Khatun, S.; (and others). Z. Phys.; 257: No. 5, 380-388(1972).

Analog states in $^{28}Si$ were identified through the $(p,\gamma)$ reaction in $^{27}Al$ in the energy range $E_p = 0.85$ to 3.0 MeV. There was hardly any indication of mixing. The Coulomb displacement energy, $\Delta E_c$, for the isobaric pair $^{28}Al-{}^{28}Si$ was obtained. A least-squares analysis was carried out on all the available experimental results on $\Delta E_c$ as a function of $\overline{Z}/A^{1/3}$. (auth)

**23540** HIGH-RESOLUTION NEUTRON RESONANCE SPECTROSCOPY IN THE keV REGION: F, Mg, Al, S, Cl, K, AND Ca. Singh, U. N. Albany, NY; State Univ. of New York (1971). 166p. University Microfilms Order No. 72-31,818. Thesis (Ph. D.).

High-resolution neutron total cross section measurements were carried out using neutron time-of-flight techniques on natural samples of F, Mg, Al, S, Cl, K, and Ca with a 200-meter flight path. These measurements were made in the energy interval of about 100 eV to a few hundred keV. The resulting neutron total cross section data were analyzed using the R-matrix multilevel formalism of Wigner and Eisenbud to obtain information about nuclear structure such as neutron resonance energies, neutron widths, neutron orbital angular momenta, spins and parities of compound levels, average level spacings, and s- and p-wave neutron strength functions. A comparison of the observed statistical distributions of the adjacent level spacings was made with the theoretical prediction of Wigner distribution. The result of this comparison is inconclusive on account of the statistically small sample size and mixtures of different $J^{\pi}$ values of levels. A comparison was made between strength functions determined from these experimental measurements and the calculated values obtained from the optical-model by using spherical-potential and coupled-channel calculations. The experimental method, theory and means of analysis and data reduction are presented in detail. (RWR)

**23541** DECAY OF $^{38}$S. Visser, J.; Lindner, L. (Instituut voor Kernphysisch Onderzoek, Amsterdam). Radiochim. Acta; 17: No. 4, 212-214(Nov 1972).

$^{38}$S was produced by the $^{40}$Ar(γ,2p) reaction and chemically separated. Gamma spectra were measured, and a half-life of 170.0 ± 0.8 min was determined. An endpoint energy of 994 ± 12 keV was deduced from extrapolation of the Kurie plot; this led to a total Q value of 2936 ± 12 keV for $^{38}$S. The results are combined in a proposed decay scheme, including branching ratios and log-ft values. (3 figures, 1 table) (RWR)

**23542** INDUCED TENSOR INTERACTION AND SECOND-CLASS CURRENTS. Eman, B.; Tadic, D. (Ruder Boskovic Inst., Zagreb). pp 247-260 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

The summary of the induced tensor contribution to second-class currents covers research on the impulse approximation, ft values and mirror transitions, capture to beta plus ratios, spectrum-shape factors for $0^- \rightarrow 0^+$ and unique nuclear β–γ angular correlations, and parity violation in heavy nuclei. (JFP)

## Nuclear Properties and Reactions, 39 ≤ A ≤ 58

*Refer also to abstracts 23519, 23524, 23525, 23528, 23539, 23540, 23554, 23578, and 23579.*

**23543** (COO-1779-63) NUCLEAR SPECTROSCOPIC STUDIES OF SHORT-LIVED NEUTRON-DEFICIENT SPECIES IN THE $f_{7/2}$ SHELL REGION. Black, J. N. (Michigan State Univ., East Lansing). 1971. 296p. Dep. NTIS.

Thesis.

The decay schemes of $^{53g}$Fe and $^{53m}$Fe were studied by the use of standard techniques for β- and γ-ray spectroscopy. The γ decay of $^{40}$Sc also was investigated by means of on-line, pulsed-beam techniques. An extensive search was conducted for γ-ray evidence to support the existence of high-spin metastable states in $^{53}$Co, $^{43}$Ti, and $^{43}$Sc. Although normal spectroscopic methods using high-resolution Ge(Li) and Si(Li) detectors were employed in most of these studies, the development of cyclotron pulsing, data routing, and other on-line techniques for the investigation of short-lived species was a significant part of this work. A pneumatic rabbit system and a helium-jet thermalizer also were utilized in many of the experiments. At least two new γ rays were observed in the decay of 8.5-min $^{53g}$Fe. These γ rays allowed the establishment of a decay scheme with levels at 0, 377.9, 1288.0, and 1619.0 keV. The $\beta^+$ decay was found to have end-point energies of 2.8, 2.4, and 1.7 MeV. Subsequent $\beta^+$–γ coincidence experiments demonstrated that the 2.8- and 2.4-MeV groups feed the ground state and first excited state, respectively. The decay of 2.5-mm $^{53m}$Fe was found to have six γ rays, which could be placed in a consistent decay scheme with levels at 0, 1328.1, 2339.6, and 3040.6 keV. Careful examination of the γ rays de-exciting this $19/2^-$ metastable state resulted in the direct observation of transitions of multipolarities of M5 and E6—the highest ever observed experimentally. The Oak Ridge Shell Model Code of French, et al., was utilized to predict the level schemes of $^{53}$Mn and $^{53}$Fe. The results were compared with other calculations and with the experimentally determined values. Partial half-lives for the γ rays de-exciting $^{53m}$Fe also were calculated and compared with experimental results. By using on-line, pulsed-beam techniques, seven γ rays were observed in the decay of 0.183-s $^{40}$Sc, and subsequently placed in a consistent decay scheme with levels at 0, 3736.9, 4491.3, 5612.7, and 7656.3 keV. With the help of the observed γ-ray intensities, $\beta^+$ feeding values and log-ft values were deduced. Various γ-ray techniques were used to conduct an exhaustive search for three-particle metastable states analogous to that observed in $^{53m}$Fe. The nuclei $^{53}$Co, $^{43}$Ti, and $^{43}$Sc were studied carefully in order to determine if γ rays were present which could be attributed to the decay of metastable states. The results of this study failed to establish the existence of γ rays which could be attributed to such states in these nuclei. If these states exist, then either the γ branch of their decay is very small or the cross section for their formation by the reactions used is very low. (61 figures, 21 tables, 127 references) (auth)

**23544** LIFETIMES OF $^{44}$Ti LEVELS. Dixon, W. R. (National Research Council of Canada, Ottawa); Storey, R. S.; Simpson, J. J. Nucl. Phys.; A202: No. 3, 579-592(1973).

Lifetimes in $^{44}$Ti have been measured by the attenuated Doppler shift following α-capture in $^{40}$Ca targets. Mean lifetimes for the 1083 keV ($2_1^+$), the 2454 keV ($4_1^+$), the 2531 keV ($2_2^+$), the 2886 keV ($2_3^+$) and the 3415 keV states of $^{44}$Ti are respectively 4.5 ± 1.1, 0.60 ± 0.11, 1.42 ± 0.20, 0.42 ± 0.14 and 0.70 ± 0.11 ps. The lifetimes of the 1904 keV ($0_2^+$) and 3176 keV states are greater than 0.7 and 3.0 ps, respectively. The level energies and experimental B(E2) values support the vibrational model as a first approximation for $^{44}$Ti. On the other hand the strong $2_2^+ \rightarrow 0_2^+$ transition (24 ± 6 W.u.) suggests the beginning of a rotational band based on a deformed particle-hole configuration. (auth)

**23545** 1f2p-SHELL NUCLEI. Structures of $^{55}$Mn, $^{55}$Fe, and $^{57}$Fe With Emphasis on High-Spin States. Sawa, Z. P. (Forskningsinstitutet foer Atomfysik, Stockholm). Phys. Scr.; 6: No. 1, 11-23(1972).

The structures of $^{55}$Mn, $^{55}$Fe, and $^{57}$Fe have been investigated by coincidence, yield, angular distribution, and linear polarization measurements of gamma-ray decay from alpha-induced reactions on $^{52}$Cr and $^{54}$Cr at $E_\alpha$ = 14.2 MeV. Several high-spin states are assigned: in $^{55}$Mn, 984 keV, $9/2^-$, 1291 keV, $11/2^-$ (both confirmed), and 2309 keV, $13/2^-$; in $^{55}$Fe, 931 keV, $5/2^-$, 1316 keV, $7/2^-$, 1408 keV, $7/2^-$, 2211 keV, $9/2^-$ 2300, keV $9/2^-$, 2539 keV, $11/2^-$ (all six confirmed), and 2814 keV, $13/2^{(-)}$, 2982 keV, $11/2^{(-)}$, 3071 keV, $11/2^-$, 3419 keV, $15/2^{(-)}$, and 3456 keV (tentative $13/2^-$); in $^{57}$Fe, 316 keV, $3/2^-$, 706 keV, $5/2^-$ (both confirmed), and 1007 keV, $7/2^-$, 1197 keV, $9/2^-$, 1357 keV, $3/2^{(-)}$, 1989 keV, $9/2^{(-)}$, 2355 keV, $11/2^-$, 2455 keV, $9/2^-$, 2879 keV, $13/2^-$, 3135 keV, $15/2^{(-)}$, 3268 keV, $13/2^{(-)}$ and 4429 keV, 4524 keV (spins undetermined). (auth)

**23546** TWO-NUCLEON TRANSFER INVESTIGATION OF THE STRUCTURE OF CALCIUM. Debevec, P. T. Princeton, NJ; Princeton Univ. (1972). 158p. University Microfilms Order No. 72-32,749.

Thesis (Ph.D.).

The two-nucleon-transfer reaction $^{42}$Ca(p,t)$^{40}$Ca was observed over the angular range of twelve to fifty-eight degrees at a bombarding energy of 41.7 MeV with 32 keV resolution on the outgoing tritons. Angular distributions for twenty-four $^{40}$Ca lines up to an excitation energy of 11.97 MeV were extracted. The (p,$^3$He) reaction was observed simultaneously. The relative excitation of the lowest $0^+$, two-particle–two-hole states of isospin T = 2, 1, and 0 was examined. The maximum cross section (at approximately twenty-two degrees) of the known T = 2, $0^+$ state was 41.2 ± 2.3 μb/sr. The previously unreported T = 1, $0^+$, two-particle–two-hole state (analog to the 1.64-MeV state in $^{40}$K) was observed at 9.386 ± 0.012 MeV with a maximum cross section of 28.0 ± 1.7 μb/sr. An upper limit on the excitation of the T = 0, $0^+$, 7.30-MeV state was 2.3 ± 0.6 μb/sr. The relative excitation of these $0^+$, two-particle–two-hole states was far from that expected for $(d^2_{3/2})^0$ pickup. The suppression of the T = 1, $0^+$ state was explained in terms of interference from $(f^2_{7/2})^0$ pickup from the four-particle–two-hole component of the $^{42}$Ca ground state. The relative excitation of the three $0^+$ states, 0.00 MeV, 3.35 MeV, and 7.30 MeV, suggested to be zero-particle–zero-hole, four-particle–four-hole, and two-particle–two-hole, respectively, and the two $2^+$ states, 3.90 MeV and 6.91 MeV, suggested to be four-particle–four-hole and two-particle–two-hole, respectively, were compared to DWBA calculations. Spectroscopic amplitudes were calculated with the wave functions of Gerace and Green. Even allowing for factor of two uncertainties in the DWBA calculations, much more strength was predicted in the two-particle–two-hole states than the four-particle–four-hole states. This result was diametrically opposed to the experimental data. The relative excitation of the lowest T = 0 and T = 1, $3^-$ and $5^-$ states was compared to DWBA calculations using the particle-hole wave functions of Kuo. While reasonable agreement with experiment was found for the $5^-$ states, the T = 1, $3^-$ state was found to be anomalously strong. (Diss. Abstr. Int., B)

**23547** EXPERIMENTAL AND THEORETICAL STUDY OF THE FRAGMENTED 2p1f SINGLE PARTICLE STATES IN $^{49}$Sc. Struve, H. Lubbock, TX; Texas Tech. Univ. (1972). 130p. University Microfilms Order No. 72-32,066.

Thesis (Ph.D.).

The excited states of $^{49}$Sc are not pure single-particle states, but are fragments of pure states. The core–particle model was applied to this isotope in an attempt to describe the fragmented negative-parity states. Five even-parity states of $^{48}$Ca were chosen as the core contribution, and were coupled to a single proton in the 2p1f shell. These coupled states formed the basis functions for diagonalization of the total Hamiltonian, which included vibrational and rotational perturbations on a pure single-particle Hamiltonian. The major components of the $7/2^-$, $5/2^-$, and $3/2^-$ fragmented states were well reproduced, but the $1/2^-$ single-particle level was not spread over a sufficient number of states. This defect is attributed to neglected core degrees of freedom. The Doppler-shift attenuation method was used to determine the mean lifetimes of six states of $^{49}$Sc and the upper limits of four other states. The measurements were made using the $^{48}$Ca(p,γ)$^{49}$Sc reaction. B(E2) and B(M1) reduced transition probabilities derived from these experimental lifetimes compared favorably with the core–particle calculations. New information was obtained about the decay scheme of $^{49}$Sc. Five $\gamma$ rays were placed in the decay scheme, and evidence to support the placement is presented. (Diss. Abstr. Int., B)

**23548** STUDY OF $^{44}$Sc USING THE $^{45}$Sc($^3$He,$\alpha\gamma$)$^{44}$Sc REACTION. Tipton, W. J. Tucson, AZ; Univ. of Arizona (1972). 74p. University Microfilms Order No. 72-31,834.

Thesis (Ph.D.).

The $^{45}$Sc($^3$He,$\alpha\gamma$)$^{44}$Sc reaction was examined at an incident $^3$He energy of 10.5 MeV to investigate the decay properties of low-lying states in $^{44}$Sc. Gamma decays from ten states below 1.05 MeV were observed. Branching ratios for the positive-parity states compared favorably with theoretical predictions. Evidence was found for rotational structure in the negative-parity states. Spins and parities were assigned based on this and previous work on $^{44}$Sc. In particular, assignments of $1^-$ and $0^+$ for the 68-keV and 146-keV states, respectively, appear quite likely. (Diss. Abstr. Int., B)

**23549** LIFETIME MEASUREMENTS IN $^{36}$Cl AND $^{40}$K. Wedberg, G. H. Jr. Bloomington, IN; Indiana Univ. (1972). 140p. University Microfilms Order No. 72-30,461.

Thesis (Ph.D.).

Electromagnetic transition rates $^{38}$Cl and $^{40}$K were studied through lifetime measurements with a double-coincidence variant of the Doppler-shift-attenuation method. An on-line computer system facilitated simultaneous measurement of many lifetimes in each nucleus. Excitation energies and mean lives were determined for 25 states. It was found that, even when effective moments are employed, the $(d_{3/2})(f_{7/2})$ model fails in its predictions of electromagnetic transition rates. The measured lifetimes lend support to the identification of the states of the $(\pi d_{3/2})^{\pm 1}(\nu 2p_{3/2})$ configurations in $^{38}$Cl and $^{40}$K. The intramultiplet M1 transitions were observed to have allowed strengths, whereas the l-forbidden intermultiplet transitions to the states of the $(d_{3/2})^{\pm 1}(f_{7/2})$ configurations had strengths that were lower by two orders of magnitude. The one exception to this picture, namely the 1.617 → 1.309-MeV transition in $^{38}$Cl, is discussed. (RWR)

**23550** NOTE ON UNIVERSITY OF CALIFORNIA, IRVINE DOUBLE-BETA-DECAY EXPERIMENT. Moe, M.; Lowenthal, D.; Reines, F. (Univ. of California, Irvine). pp 121-122 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

An experiment to observe the double beta decay of $^{48}$Ca is described and means to reduce the background are discussed. (WDM)

**23551** AVERAGE CROSS-SECTION OF THE $^{55}$Mn(n,2n)$^{54}$Mn REACTION IN A FISSION NEUTRON SPECTRUM. Francois, J. P.; Gijbels, R.; Hoste, J. (State Univ., Ghent). J. Inorg. Nucl. Chem.; 35: No. 2, 381-387(Feb 1973).

The average cross-section of the $^{55}$Mn(n,2n)$^{54}$Mn reaction has been determined experimentally. The irradiation was carried out in the BR-2 reactor (S.C.K. Mol, Belgium) at a thermal neutron flux of $1.76 \times 10^{14}$ n cm$^{-2}$ sec$^{-1}$, as determined with cobalt and silver monitors ("two foil method"). The equivalent fission neutron flux was measured with the following reference threshold detectors: $^{32}$S(n,p)$^{32}$P($\bar{\sigma}$ = 65 mb), $^{58}$Ni(n,p)$^{58,58m}$Co($\bar{\sigma}$ = 102 mb), $^{54}$Fe(n,p)$^{54}$Mn($\bar{\sigma}$ = 66 mb), $^{27}$Al(n,$\alpha$)$^{24}$Na($\bar{\sigma}$ = 0.60 mb) and $^{58}$Ni(n,2n)$^{57}$Ni($\bar{\sigma}$ = 0.004 mb). The irradiated $Mn_3O_4$ samples were measured with a calibrated Ge(Li) detector. For the mean cross-section of the $^{55}$Mn(n,2n)$^{54}$Mn reaction a value of 0.210 mb was found. Because of the small deviation of the fast component of the neutron spectrum from the unperturbed fission distribution, this value of the cross-section can be considered as a mean fission neutron cross-section. (auth)

# Nuclear Properties and Reactions, $59 \leq A \leq 89$

*Refer also to abstracts 23524, 23525, 23532, 23542, 23566, 23567, and 23579.*

**23552** (IS-T–571) SYSTEMATIC STUDY OF THE PHOTODISINTEGRATION OF GERMANIUM ISOTOPES. McCarthy, J. J. (Ames Lab., Iowa). Feb 1973. Contract W-7405-eng-82. 116p. Dep. NTIS $8.00.

Thesis.

Cross sections for the reactions $^{70}$Ge($\gamma$,n)$^{69}$Ge, $^{76}$Ge($\gamma$,n)$^{75}$Ge, $^{74}$Ge($\gamma$,p)$^{73}$Ga, $^{70}$Ge($\gamma$,np)$^{68}$Ga, $^{72}$Ge($\gamma$,np)$^{70}$Ga, $^{74}$Ge($\gamma$,np)$^{72}$Ga, and $^{76}$Ge($\gamma$,np)$^{74}$Ga were measured from threshold to 40 MeV. Cross sections were extracted from bremsstrahlung–induced yield curves of the residual radioactivity by using least structure analysis. Cross sections measured in this experiment were combined with the ($\gamma$,n) and ($\gamma$,2n) cross sections for $^{70}$Ge, $^{72}$Ge, $^{74}$Ge, and $^{76}$Ge to form total absorption cross sections. The ($\gamma$,n) and ($\gamma$,2n) cross sections were measured in a companion experiment. The total absorption cross sections for all isotopes display two prominent peaks. Peak energy and resonance width as well as peak and integrated cross sections are presented for each isotope. The primary resonance has a peak energy, width, and integrated cross section which identify it as the usual giant dipole resonance. The secondary resonance has a peak energy at about 33 MeV in $^{70}$Ge, which decreases systematically to about 27 MeV in $^{76}$Ge. The observed second resonance has a strength nearly half of the giant resonance and a larger width than the giant resonance. Isospin effects in the primary resonance are identified and compared with the predictions of isospin formalism. Present models are not able to describe adequately the systematic character of the secondary resonance. Experimental evidence is presented to suggest that the secondary resonance is present over a wide range of nuclear mass number and may very possibly be a general property of nuclear matter. (22 figures, 11 tables) (auth)

**23553** (LYCEN–7259) STUDY OF THE ODD SPHERICAL $^{89}$Zr AND $^{209}$Po NUCLEI. Do Huu Phuoc (Lyon Univ. (France). Institut De Physique Nucleaire). Sep 1972. 59p. (In French). Dep. NTIS (U. S. Sales Only).

Thesis.

Levels of $^{89}$Zr and $^{209}$Po nuclei excited by the decay of $^{89}$Nb and $^{209}$At were studied. Twenty-one excited levels of $^{89}$Zr were observed, the spins and parities of 10 of these levels being established: 587.7 keV ($1/2^-$); 1095.2 keV ($3/2^-$); 1451.1 keV ($5/2^-$); 1511.6 keV ($7/2^-$); 1627.7 keV ($5/2^+$); 1833.9 keV ($5/2^+$); 2572.8 keV ($9/2^+$); 2613.7 keV ($5/2^+$); 2754.8 keV ($7/2^+$); 3093.6 keV ($7/2^+$). In the decay of the $^{209}$At nuclei, 40 transitions were identified, 27 of these being observed for the first time. The multipolarities of 7 of these levels were determined. A preliminary theoretical interpretation was made using the unified model, each nucleus being considered to be formed of a core capable of vibration and a hole in the closed shell. This interpretation did not satisfactorily explain the experimental results. A semi-microscopic calculation using surface-delta interactions provided a better but still unsatisfactory explanation. (FR)

**23554** (RLO–1388-190) RADIATIVE CAPTURE OF FAST PROTONS BY MEDIUM MASS NUCLEI. Drake, D. M.; Whetstone, S. L.; Halpern, I. (Los Alamos Scientific Lab., N. Mex.; Washington Univ., Seattle). 1972. 44p. Dep. NTIS $4.25.

High-energy photon spectra were obtained with moderate resolution for a number of neighboring nuclei ($^{56}$Fe, $^{59}$Co, $^{58}$Ni, $^{60}$Ni, $^{61}$Ni, $^{63}$Cu, and $^{64}$Zn) in bombardments with protons (8 to 22 MeV). The shapes, magnitudes, and energy dependence of the observed spectra are found to be consistent in most of their essential features with the implications of the semidirect model for fast-nucleon capture. (auth)

**23555** CHECK ON THE CONSISTENCY OF DIFFERENTIAL $^{63}$Cu(n,$\alpha$)$^{60}$Co CROSS SECTIONS. Liskien, H.; Paulsen, A.; Widera, R. (Commission of the European Communities, Geel, Belgium). J. Nucl. Energy; 27: No. 1, 39–41(Jan 1973).

Integral results for the fission neutron averaged $^{63}$Cu(n,$\alpha$)$^{60}$Co cross-section are approximately 40% higher than values calculated from differential data using a fission spectrum. A similar discrepancy exists for the ratios $\langle\sigma\rangle$Cu/$\langle\sigma\rangle$Al. A check on the consistency of the involved differential data was performed by irradiating a Cu–Al alloy sample. Results were in good agreement with published differential data, leading to the conclusion that the origin of the discrepancy must be in the integral measurements. One possibility is the underestimation of Co impurities and thermal flux. (UK)

**23556** SEARCH FOR NEW ISOMERS WITH A RAPID EXTRACTOR. Turcotte, R. E. Montreal; McGill Univ. (1972). National Library of Canada, Ottawa.

Thesis (Ph.D.).

By using a new rapid extractor in conjunction with Ge(Li) detectors and a computer-controlled data acquisition and data analysis system developed for this experiment, a total of 27 half-lives of nuclear states (35 < A < 180) were measured in the range from 5 seconds to 70 minutes. New isomeric decays were found in $^{88m}$Nb (7.81 ± 0.6 min), $^{87m}$Zr (14.25 ± 0.08 s), $^{83m}$Y (2.85 ± 0.02 min), and $^{83m}$Sr (4.95 ± 0.12 s). In addition, new ground-state decays in $^{87}$Mo (7.58 ± 0.15 min), $^{87}$Nb (3.10 ± 0.03 min), $^{88}$Nb (14.57 ± 0.06 min), $^{84}$Zr (10.5 ± 0.6 s), $^{85}$Zr (7.85 ± 0.04 min), $^{82}$Y (22.8 ± 0.34 min), $^{83}$Y (7.06 ± 0.08 min), and $^{68}$As (2.53 ± 0.03 min) were observed. Of these, $^{87}$Mo, $^{84}$Zr, $^{87m}$Zr, $^{82}$Y, $^{83m}$Sr, and $^{68}$As were previously unreported. Significant additions or differences appear in all but $^{85}$Zr. (Diss. Abstr. Int., B)

**23557** CROSS-SECTION FOR THE REACTION $^{65}$Cu(p,pn)$^{64}$Cu IN THE ENERGY RANGE 23 TO 102 MeV. Newton, D. A. (McGill Univ., Montreal); Sarkar, S.; Yaffe, L.; Moore, R. B. J. Inorg. Nucl. Chem.; 35: No. 2, 361-370(Feb 1973).

The cross section for the reaction $^{65}$Cu(p,pn)$^{64}$Cu, a widely-used beam monitor reaction, has been measured for proton energies in the range 23 to 102 MeV. A Faraday cup, in the external beam facility, was used to monitor the proton beam intensity. (auth)

**23558** $\gamma$-RAY SPECTRA FROM AN (n,$\gamma$) REACTION IN THE ISOTOPES OF ZINC. Bogdanov, A. P.; Soroka, A. V. (Inst. of Physics, Minsk). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Mat. Navuk; No. 6, 96-103(1972). (In Belorussian).

The $\gamma$-spectra arising from thermal neutron capture by the isotopes $^{64,66,67,68}$Zn were determined with a single crystal spectrometer and a Ge(Li) detector. The energy, intensity, and isotropic identity of the majority of $\gamma$-lines emitted were determined. A scheme of $\gamma$-transitions for the isotopes $^{65,67,68,69}$Zn was proposed. An anticorrelation probability of excitation of the lower p-levels in (d,p)- and (n,$\gamma$)-reactions was discovered for even-odd isotopes of Zn. (tr-auth)

## Nuclear Properties and Reactions, $90 \leq A \leq 149$

*Refer also to abstracts 23524, 23525, 23542, and 23614.*

**23559** (FRNC-TH-313) MEASUREMENT OF THE RATIO BETWEEN TWO QUADRUPOLE MOMENTS OF $^{133}$La. Rimbert, J. N. (Paris Univ., Orsay (France)). 1971. 50p. (In French). Dep. NTIS (U. S. Sales Only) $4.50.

The magnetic and quadrupole moments of two particular levels of $^{133}$La were measured: the deformed $\frac{3}{2}^-$, 535.4-keV level, having a 60 ns half-life, and the $\frac{3}{2}^+$, 130.7-keV level, having a 1.2 ns half-life. If systematic errors in the field gradient are neglected, the values obtained for the magnetic moment (g = 1.4; N = 2.1 magnetons) and the quadrupole moment (Q = 1.6 barns; deformation = 0.47) of the 535.4-keV level confirm the existence of shape isomers. To remove this objection, the ratio between the quadrupole moments at 130.7 and 535.4 keV (Q(535.4)/Q(130.7)) was measured using the differential perturbed angular correlation method. The value obtained for this ratio demonstrates that the quadrupole moments are very different. The hypothesis that two levels of the $^{133}$La excitation scheme are associated with different equilibrium forms of the same nucleus is confirmed. The 1.2 ns half-life of the 130.7-keV level enables differential correlations to be realized, but imposes a low time resolution (2 ns at 58 keV). It was necessary to make improvements to the equipment previously used to measure Q(535.4) in order to establish the existence of periodic perturbations of the order of 3500 Megacycles at 60 keV and to measure at this energy the mean lives of approximately 1 ns duration. (FR)

**23560** (FRNC-TH-334) DEFORMATION OF NUCLEI IN THE LANTHANUM REGION. Deleplanque, M. A. (Paris Univ., Orsay (France)). 1972. 68p. (In French). Dep. NTIS (U. S. Sales Only).

Thesis.

The deformation of $^{131}$La and $^{133}$La nuclei was studied. The deformation of the 535.3-keV, T = 60 ns level of $^{133}$La, obtained from the $^{133}$Cs($\alpha$,4n)$^{133}$La reaction, was compared to that of the low energy levels, the possibility of the de-excitation of rotational or quasi-rotational bands to these states being studied. An attempt was made to establish the existence of a narrower rotational band around the 535-keV level, constituting, above a certain spin, the group of yrast levels. The lines were selected by applying delayed coincidence techniques to the 58-keV transition, by which the isomeric state de-excites. As an analogous situation seems to occur in $^{131}$La for 108- and 169-keV radiations having a 170 ns half-life, the multipolarities of these two transitions were determined by measuring the $\alpha_k$ conversion coefficients and by establishing the level schemes. This was accomplished by the direct measurement of spectral series and multidimensional $\gamma-\gamma$ coincidences. It was shown that certain effects such as the Coriolis coupling, which are in general of little importance for highly deformed nuclei, may become dominant in transition regions. (FR)

**23561** (INDC(CCP)–30/U) NUCLEAR PHYSICS RESEARCH IN THE USSR. (Collected Abstracts) No. 12. (International Nuclear Data Committee). Dec 1972. 94p. Dep. NTIS (U. S. Sales Only).

The abstracts in this collection were drawn from various sources, such as papers presented at conferences and submitted to physics journals. (RWR)

**23562** (INDC(CCP)–31/U) NUCLEAR PHYSICS RESEARCH IN THE USSR. (Collected Abstracts) No. 11. (International Nuclear Data Committee). Dec 1972. 65p. Dep. NTIS (U. S. Sales Only).

The papers in this collection were drawn from various sources, such as preprints, conference presentations, and physics journals. (RWR)

**23563** (INIS-mf–327) STUDY OF SPHERICAL EVEN–EVEN AND ODD-PROTONS N = 82 NUCLEI WITH A QUASI-PARTICLE MODEL. Waroquier, M.E.L. (Ghent Rijksuniversiteit (Belgium)). 1971. 140p. (In Dutch). INIS.

The Bogolyubov–Valatin transformation is applied to general shell models; thus, the Hamiltonian can be expressed in quasiparticle operators. The matrix is diagonalized by the Tamm–Dancoff approximation. Correlations between two or more quasi-particle excitations are treated with the random-phase approximation, and the Bardeen–Cooper–Schieffer theory is applied to nuclear models. The energy spectra of the even-even nuclei $^{136}$Xe, $^{138}$Ba, $^{140}$Ce, $^{142}$Nd, and $^{144}$Sm and of odd-proton $^{137}$Cs, $^{139}$La, $^{141}$Pr, $^{143}$Pm, and $^{145}$Eu are calculated and compared with experimental values. Formulas for the computation of transition probabilities, magnetic dipole moments, and quadrupole moments are presented. (INIS)

**23564** (INR-P–1417) CROSS SECTIONS FOR THE (n,n') AND (n,2n) REACTIONS IN THE $^{113}$In AND $^{204}$Pb NUCLEI. Decowski, P.; Grochulski, W.; Karolyi, J.; Marcinkowski, A.; Piotrowski, J.; Saad, E.; Wilhelmi, Z. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 17p. Dep. NTIS (U. S. Sales Only).

The cross sections for the (n,n') and (n,2n) reactions with $^{113}$In and $^{204}$Pb target nuclei were measured by the activation method in the neutron energy range from 13 MeV to 18 MeV. The results were compared with the predictions of the compound-nucleus theory. Angular momentum effects and the $\gamma$ decay of unbound states were taken into account. (3 figures, 4 tables) (auth)

**23565** (JINR–P6-6876) INVESTIGATION OF THE DECAY OF NEODYMIUM AND PRASEODYMIUM NUCLIDES WITH MASS NUMBER A = 136. Buttsev, V. S.; Vylov, Ts.; Gromov, K. Ya.; Kalinnikov, V. G. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1972. 21p. (In Russian). Dep. NTIS (U. S. Sales Only).

The decay of the chain $^{136}\mathrm{Nd} \xrightarrow{55\ \mathrm{min}} {}^{136}\mathrm{Pr} \xrightarrow{12.9\ \mathrm{min}} {}^{136}\mathrm{Ce}$ was studied. About 100 new $\gamma$ transitions were observed in the decay of $^{136}$Nd and $^{136}$Pr, and their assignments were determined. The multipole types were determined for a number of them. The decay scheme of $^{136}$Nd[(55.0 ± 1.5)min] is proposed for the first time, and the decay scheme $^{136}$Pr[(12.9 ± 0.4)min] is substantially completed. The levels in the decay scheme of $^{136}$Pr are confirmed by the $\gamma-\gamma$ coincidence method. The nature of $^{136}$Pr and $^{136}$Ce levels is discussed in the quasi-particle approximation. (6 figures, 3 tables) (auth)

**23566** (KFK-1/72-1) COMPILATION AND SURVEY OF DATA ON LEVELS OF EVEN-EVEN NUCLEI $Z \leq 48$, $N \geq 50$. Wood, L. (Kernforschungszentrum, Karlsruhe (West Germany). Institut Fuer AngeWandt Kernphysik). Sep 1972. 92p. Dep. NTIS (U. S. Sales Only) $6.75.

Up-to-date information on nuclear states of even–even nuclei in the region $36 \leq Z \leq 48$, $50 \leq N \leq 74$ is presented. The compilation of data, based on all experimental techniques available in the literature, is condensed in level diagrams, each for one specific method and arranged by nuclide. (auth)

**23567** (LUIP-CR-72-14) EMISSION OF HELIUM NUCLEI IN HEAVY ION INTERACTIONS AT ENERGIES ≥ 100 MeV/NUCLEON. Kullberg, R.; Otterlund, I. (Lund Univ. (Sweden). Dept. of Cosmic High Energy Physics). Dec 1972. 35p. Dep. NTIS (U. S. Sales Only).

The energy and angular distributions of helium particles emitted in interactions between nuclei in cosmic radiation and nuclei in photoemulsions at energies ≥100 MeV/nucleon have been studied. The data obtained cannot be interpreted on the basis of a statistical decay of excited nuclei. For example, it is found that more than 28% of the helium nuclei are emitted in processes different from simple evaporation. The differential energy distribution of the helium nuclei in the energy interval (40 to 200) MeV can be represented by the relation $N(E)dE = \text{const } E^{-a}\, dE$, where $a = 1.2$. The large spread in angles and energies of the fast helium particles emitted in heavy ion interactions can to a certain degree be understood, if it is assumed that interactions between nucleons and clusters of nucleons occur. (auth)

**23568** (RD/B/M-2453) DATA FOR THE CALCULATION OF GAMMA RADIATION SPECTRA AND BETA HEATING FROM FISSION PRODUCTS (REVISION 2). Tobias, A. (Central Electricity Generating Board, Berkeley (England). Berkeley Nuclear Labs). Oct 1972. 215p. (Fredswg/P-(72)12). Dep. NTIS (U. S. Sales Only).

A complete set of available data on the properties of the fission products of $^{235}$U, $^{238}$U, $^{239}$Pu, $^{240}$Pu, and $^{241}$Pu is presented. The compilation covers fission yield, half-life, gamma radiation energy and intensity, thermal neutron capture cross-section, total decay energy, mean beta energy and energy of conversion electrons plus X radiation. The gamma radiation spectrum is given as the number of photons per 100 disintegrations. (auth)

**23569** NUCLEAR MATRIX ELEMENTS IN THE FIRST-FORBIDDEN $\beta$ DECAY OF $^{125}$Sb. Schweitzer, J. S.; Simms, P. C. (Purdue Univ., Lafayette, IN). Nucl. Phys.; A202: No. 3, 602-608(1973).

Nuclear matrix elements in the $\frac{7}{2}^+$ (444 keV $\beta^-$) $\frac{9}{2}^-$ (177 keV $\gamma$) $\frac{11}{2}^-$ $\beta-\gamma$ cascade in $^{125}$Sb have been extracted from the available experimental data. A significant cancellation in the Coulomb-enhanced matrix element combination permits good limits of error to be placed on the individual matrix elements, even though there is not a large amount of experimental data available. (auth)

**23570** ANALOG STATES OF $^{140}$La LEVELS. Lamehi-Rachti, M. (CEN, Saclay, France); Cassagnou, Y.; Foissel, P.; (and others). Nucl. Phys.; A202: No. 3, 609-630(1973).

Analog states in $^{140}$Ce have been studied through elastic and inelastic proton scattering on $^{139}$La in the energy range $E_p$ = 9–12 MeV. We have shown that the 14 first excited states of $^{140}$La can be described by the two configurations $[(g_{7/2})_p \otimes (f_{7/2})_n]$ and $[(d_{5/2})_p \otimes (f_{7/2})_n]$ according to the assumption of Kern et al. The elastic scattering results are in complete agreement with the $^{139}$La(d,p) ones. The study of the inelastic scattering to the 166 keV excited state of $^{139}$La($d_{5/2}$ level), which gives a direct and sensitive test of the $[(d_{5/2})_p \otimes (f_{7/2})_n]$ components, has confirmed that only these two configurations are important and that the relative intensities of the two configurations deduced from (d,p) experiments are correct. On the other hand, the two sets of theoretical wave functions which exist are not able to reproduce experimental results. We are able to confirm that the proton peak observed at $E_p$ = 10.3 MeV in the $^{140}$Ce(e,e′p)$^{139}$La reaction by Shoda et al. corresponds to the analog of the $1^-$ state at 466 keV in $^{140}$La. (auth)

**23571** $^{144}$Nd(d,p) AND $^{144}$Nd(d,t) REACTIONS AND ISOBARIC ANALOG RESONANCES IN $^{144}$Nd(p,$p_0$) AND $^{144}$Nd(p,p′). Gales, S.; Lessard, L.; Foster, J. L., Jr. (Univ. of Montreal). Nucl. Phys.; A202: No. 3, 535-556(1973).

The reactions $^{144}$Nd(d,p) and $^{144}$Nd(d,t), at an incident deuteron energy of 12.6 MeV, have been investigated with an energy resolution of about 16 keV, and excitation functions for the reactions $^{144}$Nd(p,$p_0$) and $^{144}$Nd(p,p′) have been measured from 9.3 to 12 MeV incident proton energies. The analysis of the analog resonances observed in the excitation functions is compared with the results of the $^{144}$Nd(d,p) experiment. (auth)

**23572** MAGNETIC MOMENTS OF $^{127g}$Te AND $^{129g}$Te. Silverans, R. E.; Coussement, R.; Schoeters, E.; Vanneste, L. (Leuven Univ., Heverlee, Belgium). Nucl. Phys.; A202: No. 3, 467-472(1973).

Anisotropies of several $\gamma$-rays in the decay of $^{127g}$Te and $^{129g}$Te implanted in iron have been observed in nuclear orientation experiments. The magnetic moments of both ground states were derived: $\mu(\frac{3}{2}^+) = 0.66 \pm 0.05$ n.m. for $^{127g}$Te and $\mu(\frac{3}{2}^+) = 0.66 \pm 0.05$ n.m. for $^{129g}$Te. These results, compared to predictions from pairing-plus-quadrupole theory, suggest a pure single-quasiparticle character for these states. (auth)

**23573** NEUTRON HOLE STATES IN $^{91}$Mo AND $^{93}$Mo STUDIED BY THE (p,d) REACTION. Moinester, M. A. (Tel-Aviv Univ., Israel); Finkel, G.; Alster, J.; Martin, P. Nucl. Phys.; A202: No. 3, 473-496(1973).

The level structure of $^{91}$Mo and $^{93}$Mo has been investigated with the $^{92,94}$Mo(p,d)$^{91,93}$Mo reactions at $E_p$ = 40 MeV. Deuteron angular distributions were measured for 26 groups in $^{91}$Mo up to 9 MeV excitation (including five analog states), and 24 groups in $^{93}$Mo up to 13 MeV excitation (including five analog states). The $l_n$ values and transition strengths were determined from a DWBA analysis. Several new spin and parity assignments were made. The results are compared to the $^{92,94}$Mo(d,t), $^{90,92}$Zr(p,d), $^{88}$Sr(d,t) and $^{92,94}$Mo(d,$^3$He) reactions. All results are compared to simple sum-rule predictions. The summed transition strengths in $^{91,93}$Mo agree reasonably well with sum-rule predictions except for the $1f_{5/2}$ transitions. The $1f_{5/2}$ strength, and to a lesser degree the $1g_{9/2}$ and 2p strengths, are severely fragmented in $^{93}$Mo in contrast to $^{87}$Sr, $^{89}$Zr and $^{91}$Mo. We show that the N = 50 core in the $^{92}$Mo ground state is very well closed. In the $^{94}$Mo ground state, the neutrons beyond the N = 50 core occupy only about 65% of the $2d_{5/2}$ orbit. For the analog states in $^{91,93}$Mo, neither the effective binding nor the separation energy form factor gives consistently better results as regards both the $C^2S$ values and the quality of the DWBA fits. The Q-value of the $^{92}$Mo(p,d)$^{91}$Mo reaction was found to be $Q = -10.432 \pm 0.025$ MeV. (auth)

**23574** DIRECTIONAL CORRELATIONS OF CASCADING GAMMA TRANSITIONS SUBSEQUENT TO THE DECAY OF $^{129g}$Te. Blaskovich, N. Jr. Morgantown, WV; West Virginia Univ. (1972). 212p. University Microfilms Order No. 73-832.

Thesis (Ph. D.).

Gamma–gamma directional correlation studies were conducted at several cascading gamma transitions observed in the decay of $^{129g}$Te. Correlation functions were determined for each of the following cascades: 459–27 keV, 250–27 keV, 1084–27 keV, 342.6–459 keV, 342.8–741 keV, 281–250 keV, 281–278 keV, and 209–278 keV. These measurements resulted in the following spin assignments being made to each of the respective nuclear energy levels: ground state, 7/2; 27 keV, 5/2; 278 keV, 5/2; 487 keV, 5/2; 559 keV, 3/2; 769 keV, 7/2; 830 keV, 3/2(5/2); and 1111 keV, 5/2. Various possibilities for the multipole character of each of the transitions investigated were determined on the basis of results of previous internal conversion studies made of the 27-keV transition. (RWR)

**23575** NUCLEAR SPECTROSCOPY OF $^{101}$Mo BY SUB-COULOMB STRIPPING. Sievers, W. L. Lawrence, KS; Univ. of Kansas (1972). 85p. University Microdilms Order No. 72-32,931.

Thesis (Ph. D.).

The sub-Coulomb stripping method was employed to study $^{101}$Mo with 3.75-MeV deuterons. Proton groups corresponding to states in $^{101}$Mo at excitation energies of 0, 57, 239, 349, 480, 561, 812, 851, and 898 keV were observed. The states at 349, 561, and 851 have not been reported previously. The ground state and the excited state at 349 keV were shown to be $1/2^+$ states with spectroscopic factors of 0.42 and 0.16, respectively. Tentative assignments of $l_n = 2$ were made for the states at 57, 239, 290, and 480 keV. If these states have a $3/2^+$ nature, the spectroscopic factors are 0.25, 0.09, 0.12, and 0.11, respectively. An improved Q value for the $^{100}$Mo(d,p)$^{101}$Mo reaction was found; The new value is 3161 ± 6 keV. (Diss. Abstr. Int. B)

**23576** STUDY OF THE EXCITED STATES OF $^{119}$Sn BY THE DECAY OF $^{119g+m}$In. Jacobs, E.; De Frenne, D. (Natuurkundig Laboratorium, Ghent). Z. Phys.; 257: No. 5, 402–409(1972).

The decay of $^{119g+m}$In to the excited states of $^{119}$Sn was investigated. $^{119}$In was produced by the $^{120}$Sn($\gamma$,p)$^{119}$In reaction on an enriched $SnO_2$ target. The isomeric transition of 311.25 keV to the $^{119}$In ground state was observed. In the beta decay of $^{119m}$In excited states at 23.9, 920.5, 921.4, 1089.0, 1187.9, and 1249.6 keV in $^{119}$Sn with $J^\pi$ values of $\frac{3}{2}^+$, $\frac{3}{2}^+$, $\frac{5}{2}^+$, $\frac{5}{2}^+$, $\frac{3}{2}^+$, and $\frac{1}{2}^+$, respectively, are fed. In the decay of the $^{119}$In ground state only the $\frac{7}{2}^+$ level in $^{119}$Sn at 787.0 keV is fed. (3 figures, 1 table) (auth)

**23577** DECAY OF $^{93}$Sr. Herzog, W.; Grimm, W. (Univ., Mainz). Z. Phys.; 257: No. 5, 424–439(1972). (In German).

The nuclide $^{93}$Sr was isolated by chemical separation methods after thermal-neutron-induced fission of $^{235}$U, and its decay properties were investigated by employing scintillation and semiconductor spectrometers and coincidence techniques. A half-life of 7.43 ± 0.03 min and a $Q_\beta$-value of 4.3 ± 0.2 MeV were found. Out of 74 gamma rays, 55 transitions, representing 97% of the observed gamma-ray intensity, could be placed in a decay scheme comprising 22 excited states of $^{93}$Y. (4 figures, 4 tables) (auth)

**23578** THERMAL NEUTRON CROSS SECTION AND THE RESONANCE INTEGRAL OF $^{146}$Nd, $^{148}$Nd, $^{150}$Nd, AND $^{41}$K. Kim, J. I.; Gryntakis, E. (Technical Univ., Munich). Radiochim. Acta; 17: No. 4, 191-195(Nov 1972).

The thermal-neutron cross sections and resonance integrals of $^{146}$Nd, $^{148}$Nd, $^{150}$Nd, and $^{41}$K were measured by neutron activation by using a Cd filter and Au as a comparator. A comparison technique was applied to measure, primarily, the effective cross sections. The thermal neutron cross section and resonance integrals were calculated from knowledge of the effective cross section, the Cd ratio, and the epithermal index of the irradiation site. The values found for $\sigma_0$ and $I_0'$ (in barns) are as follows: $^{146}$Nd: 1.31 ± 0.06, 2.01 ± 0.14; $^{148}$Nd: 2.45 ± 0.14, 12.72 ± 1.00; $^{150}$Nd: 0.94 ± 0.02, 12.01 ± 0.20; $^{41}$K: 1.28 ± 0.06, 0.70 ± 0.03. (2 figures, 2 tables) (auth)

**23579** ESTIMATION OF CROSS-SECTION MAXIMA FOR (–, xn) EXCITATION FUNCTIONS. Roehm, H. F.; Muenzel, H. (Kernforschungszentrum, Karlsruhe, Ger.). Radiochim. Acta; 17: No. 4, 195-199(Nov 1972).

A procedure for estimating the cross-section maxima, $\sigma_{max}$, of ($\alpha$,xn), (d,xn), and (p,xn) excitation functions for target nuclei with atomic numbers ranging from 20 to 83 is given. The deviation of the experimental values from the trends for $\sigma_{max}$ is generally less than 50%. (4 figures) (auth)

**23580** HALF-LIFE OF $^{103m}$Rh. Guenther, E.; Knauf, K.; Walz, K. F. (Physikalisch-Technische Bundesanstalt, Brunswick). Int. J. Appl. Radiat. Isotop.; 24: No. 2, 87-89(Feb 1973).

The half-life of $^{103m}$Rh was measured using a liquid scintillation spectrometer, a $2\pi$-proportional flow counter, and a thin NaI(Tl) crystal. The mean value of the three results is (56.116 ± 0.009) min. The sources were prepared by a nuclide generator and had a radiochemical purity greater than 99.99%. (auth)

**23581** ISOMERIC-YIELD RATIOS OF $^{117}$Cd IN THE (n,$\gamma$) AND (d,p) REACTIONS. Tang, C. W.; Eng, R. L.; Coryell, C. D. (Massachusetts Inst. of Tech., Cambridge). J. Inorg. Nucl. Chem.; 35: No. 2, 371-380(Feb 1973).

An isomeric-yield ratio, $\sigma_m/\sigma_g = 0.24 \pm 0.03$, was determined for the production of 2.4-h $^{117g}$Cd and 3.4-h $^{117m}$Cd in the (n,$\gamma$) reaction by measuring the relative intensities of $\gamma$-rays of the $^{117}$Cd isomers and also of the 38-m $^{117g}$In and 1.93-h $^{117m}$In daughters milked from the $^{117}$Cd. In the (d,p) reaction, the isomeric yield-ratio was found to be 0.60 ± 0.08. The reason for these ratios to be higher in $^{117}$Cd than in $^{115}$Cd is discussed in terms of the possibility of inversion of the level position of a low-lying $^5\!/_2$ state with respect to that of a neighbouring $^7\!/_2$ or $^9\!/_2$ state in going from $^{115}$Cd to $^{117}$Cd. The lowering of a $^7\!/_2$ or $^9\!/_2$ state below the $^5\!/_2$ state in $^{117}$Cd affords an intermediate state to channel transitions from the $^5\!/_2$ states to the $^{11}\!/_2{}^{-}$ $^{117m}$Cd, thus raising the isomer ratio. (auth)

**23582** AVERAGE CROSS-SECTION OF THE $^{103}$Rh(n,2n)$^{102}$Rh AND $^{103}$Rh(n,2n)$^{102m}$Rh REACTIONS IN A FISSION NEUTRON SPECTRUM. Francois, J. P.; Gijbels, R.; Hoste, J. (State Univ., Ghent). J. Inorg. Nucl. Chem.; 35: No. 2, 389-394(Feb 1973).

For the determination of the mean cross-sections of the $^{103}$Rh (n,2n)$^{102,102m}$Rh reactions in the BR-2 reactor, the equivalent fission neutron flux was determined with four reference threshold reactions: $^{58}$Ni(n,p)$^{58,58m}$Co, $^{27}$Al(n,$\alpha$)$^{24}$Na, $^{55}$Mn(n,2n)$^{54}$Mn and $^{58}$Ni(n,2n)$^{57}$Ni. The equivalent fission flux, determined with the $^{58}$Ni(n,p)$^{58,58m}$Co reaction, was corrected for "burn up" of both cobalt isomers. In order to carry out this correction, the thermal flux was determined by irradiation of a dilute cobalt–aluminum alloy, and was $6.99 \times 10^{12}$ n cm$^{-2}$ sec$^{-1}$. $^{102,102m}$Rh, formed by the (n,2n) reaction, was separated from the high $^{192}$Ir activity by precipitating rhodium from a dilute hydrochloric acid solution after addition of mercury(I) chloride. $^{192}$Ir was formed by (n,$\gamma$) reaction on iridium, which is always present as an impurity in rhodium sponge. The absolute measurements of $^{102}$Rh and of $^{102m}$Rh were performed with a Ge(Li) detector of known detection efficiency. As the effective energies for the $^{103}$Rh(n,2n)$^{102,102m}$Rh and the $^{55}$Mn(n,2n)$^{54}$Mn reactions are approximately equal, the cross-sections for the $^{103}$Rh(n,2n) reactions have been referred to the $^{55}$Mn(n,2n) ($\bar{\sigma} = 0.21$ mb) reaction. For the mean cross-sections of the $^{103}$Rh(n,2n)$^{102}$Rh and the $^{103}$Rh(n,2n)$^{102m}$Rh reactions, values of 0.60 and 0.24 mb, respectively, have been found. (auth)

**23583** COLLECTIVE PAIRING BANDS. Hansen, O.; Nathan, O. (Niels Bohr Institutet, Copenhagen). Comments Nucl. Particle Phys.; 5: No. 4, 101-106(Jul 1972).

The concept of band structure, that is, a series of related states, is well established in atomic, molecular and nuclear physics. Where a band indicates a cooperative motion of many particles the concept of a collective mode may be employed. A classical example of a collective mode in nuclear physics is the rotational band of a nucleus with a quadruple deformed equilibrium shape. While collective bands have usually been considered as belonging to one nucleus there is no fundamental reason why this must be so. In order to demonstrate such an extension of the concept of collective bands, data are given for reactions in the Sn and Pr regions. The ground states of the even Sn nuclei have a spherical equilibrium shape and are well described within the pairing coupling scheme as superfluid systems. Lead-208 is a good example of a doubly closed shell nucleus and it may be expected that $0^+ \rightarrow 0^+$ state transitions would show a pattern different from the superfluid situation. (UK)

## Nuclear Properties and Reactions, $150 \leq A \leq 189$

*Refer also to abstracts 23524, 23525, 23532, 23542, 23578, 23579, 23615, and 23617.*

**23584** (KFK-1739) EXPERIMENTS ON PARITY NONCONSERVATION IN NUCLEAR FORCES. Jenschke, B. (Kernforschungszentrum, Karlsruhe (West Germany). Institut Fuer Experimentelle Kernphysik). Dec 1972. 95p. (In German). Dep. NTIS (U. S. Sales Only) $6.75.

Parity violation in nuclear forces was found by measuring the circular polarization of $\gamma$ rays emitted by unpolarized sources. The circular polarization was determined with a 0.5-Hz Compton forward polarimeter. To get the necessary statistics, strong $\gamma$ sources were used and the scattered quanta were detected by integration. Phenomena imitating polarization, discussed in detail, were investigated in specific experimental arrangements. The contributions of polarized bremsstrahlung were calculated, and the calculations were verified by control measurements on $^{198}$Au, $^{177}$Lu, $^{32}$P, and $^{183}$Ta. The results obtained are as follows: $^{180}$Hf (501 keV), $P_\gamma = -(22.8 \pm 1.5) \times 10^{-4}$; $^{181}$Ta (482 keV), $P_\gamma = -(3.8 \pm 1.0) \times 10^{-6}$; $^{159}$Tb (363 keV), $P_\gamma \leq 10^{-3}$; $^{182}$W (1189 keV), $P_\gamma = -(0.1 \pm 1.1) \times 10^{-5}$; and $^{175}$Lu (343 keV), $P_\gamma = -(1.5 \pm 6) \times 10^{-6}$. The circular polarizations found are compared with the results of other authors and with the estimates obtained by using a weak nucleon–nucleon interaction. (26 figures, 12 tables) (auth)

**23585** RADIOCHEMICAL STUDY OF THE FISSION OF TANTALUM IN THE REACTIONS $^{181}$Ta($^{20}$Ne,f) AND $^{181}$Ta($^{22}$Ne,f). Gvozdev, B. A.; Mal'tseva, N. S.; Oganesyan, Yu. Ts.; Chuburkova, I. I.; Shcheglovskii, Z. Sov. Radiochem. (Engl. Transl.); 14: No. 2, 326-330(1972).

Translated from Radiokhimiya; 14: No. 2, 314-318(1972).

The yields from the reactions $^{181}$Ta($^{20}$Ne,f) and $^{181}$Ta($^{22}$Ne,f) at 175 MeV were measured to study the widths of the charge and mass distributions of the resulting fission products. The chemical methods for separation of the various products are described in some detail. The results of the experiment suggest that some of the previous work on the widths of fission-fragment yield curves may be in error. (4 figures, 1 table) (RWR)

**23586** EFFECT OF THE SHORT-RANGE RESIDUAL INTERACTION ON CALCULATIONS OF THE PARITY-VIOLATING CIRCULAR POLARIZATION IN TANTALUM. Missimer, J. H. Stony Brook, NY; State Univ. of New York (1972). 97p. University Microfilms Order No. 73-1127.

Thesis (Ph. D.).

A detailed investigation of the effect of the short-range correlations produced by the Reid soft-core potential on the one-vector meson-exchange contribution to the circular polarization of photons emitted in the 482-keV transition in $^{181}$Ta shows that the contribution is reduced by a factor of two and one-half by these correlations. The Bethe–Goldstone equation in nuclear matter and a relation between Bessel functions and harmonic oscillator wave functions provide a method of calculating correlated wave functions for the Nilsson shell model used to represent the tantalum nucleus. Comparison with other theoretical investigations indicates that the sign of the vector meson contribution may have been computed incorrectly in previous calculations, and also that deficiencies in both Nilsson calculations and Woods–Saxon calculations preclude at this time a definitive analysis of which models of the weak Hamiltonian are most realistic. (Diss. Abstr. Int. B)

**23587** HYPERFINE STRUCTURE INVESTIGATION OF $^{153}$Dy, $^{155}$Dy, AND $^{157}$Dy. Rosen, A.; Nyqvist, H. (Chalmers Tekniska Hoegskola, Goteborg). Phys. Scr.; 6: No. 1, 24-36(1972).

The magnetic dipole and the electric quadrupole interaction constants a and b have been measured for the neutron-deficient dysprosium isotopes $^{153}$Dy (6 h), $^{155}$Dy (10 h) and $^{157}$Dy (8.1 h) using the atomic-beam magnetic resonance method. The results are $^{157}$Dy $|a| = 121.605(4)$ MHz, $|b| = 564.65(7)$ MHz, $b/a < 0$; $^{155}$Dy $|a| = 136.5(5)$ MHz, $|b| = 421(5)$ MHz, $b/a < 0$; $^{153}$Dy $|a| = 123.5(8)$

MHz, |b| = 65(40) MHz, b /a >0. For the evaluation of the corresponding nuclear moments of these isotopes a theoretical analysis of the hyperfine structure has been performed using an effective hyperfine structure Hamiltonian within the $4f^{10}$ configuration. The values of $(r^{-3})$ needed for the calculation have been obtained using relativistic self-consistent-field wave functions. The analysis yields the following nuclear moments: $^{157}$Dy: $\mu_I = -0.30(3)$ n.m., Q = +1.22(13) barn; $^{155}$Dy: $\mu_I = -0.34(3)$ n.m., Q = +0.91(10) barn; $^{153}$Dy: $\mu_I = -0.71(9)$ n.m., Q = −0.14(8) barn. The quadrupole moments are corrected for the Sternheimer effect. A comparison with recent moment calculations using the unified nuclear model is made. (auth)

**23588** ANGULAR DISTRIBUTIONS OF 12 MeV DEUTERONS INELASTICALLY SCATTERED BY $^{162}$Dy. Sterba, F.; Sterbova, J.; Tozkos, M. (Charles Univ., Prague). Czech. J. Phys.; 23: No. 1, 25-32(1973).

The inelastic scattering of 12.1-MeV deuterons by $^{162}$Dy was investigated. Angular distributions of the inelastic groups were measured in the region from 30 to 150°. A magnetic spectrograph was used to record the deuteron spectra with an overall energy resolution of ~15 keV. For the strongly populated collective levels the shape dependence of the angular distributions on transferred angular momentum was studied. The rather different shapes for the rotational and vibrational $2^+$ levels were observed. The tentative assignment of some other excited states populated by the (d,d′) process in $^{162}$Dy was deduced. (auth)

**23589** GAMMA RAYS OF THE DECAY OF 11.4 MIN IN $^{163}$Yb. de Boer, F. W. N.; Goudsmit, P. F. A.; Meijer, B. J. (Inst. of Nuclear Physics Research, Amsterdam). Radiochim. Acta; 17: No. 4, 218(Nov 1972).

$^{163}$Yb was produced by the $^{166}$Er($^3$He,6n) reaction at 60 MeV. The spectrum was measured with an anti-Compton Ge(Li) arrangement, having a Compton-suppression factor of about 10 for 1-MeV gamma rays. A total to 58 γ rays was found to decay with a half-life of (11.4 ± 0.5) min. The energies and intensities of these gamma rays are tabulated. (1 table) (RWR)

**23590** ANISOTROPY IN ANGULAR DISTRIBUTION OF FRAGMENTS OF PHOTOFISSION AT HIGH ENERGIES. Demekhina, N. A.; Kasilov, V. I.; Mitrofanova, A. V.; Ranyuk, Yu. N.; Sorokin, P. V. (Physical-Technical Inst., Kharkov). Yadern Fiz.; 16: No. 5, 911-915(1972). (In Russian).

Fragmented angular distributions of $^{238}$U, $^{209}$Bi, $^{197}$Au and $^{181}$Ta nucleus fission have been measured with micaceous detectors for energy range $E_{\gamma\,max}$ from 600 up to 5100 MeV. It is shown, that fragment angular distributions of $^{238}$U fission are isotropic within 3%, while in the case of $^{209}$Bi, $^{197}$Au and $^{181}$Ta nuclei an anisotropy of about 10−20% is observed with primary emission of fragments in the photon beam direction. (auth)

**23591** TOTAL NEUTRON CROSS SECTION OF Ho. Farooque, M. (Atomic Energy Centre, Dacca, Bangladesh); Enayetullah, M.; Das, P. J. Nucl. Energy; 27: No. 1, 43-45(Jan 1973).

The total neutron cross section of Ho was determined by the transmission method using neutrons from the T(d,n)$^4$He reaction emerging at 0 and 70° angles. The experiment was performed in the range 14 to 19-MeV at intervals of approximately 150 keV. From the data the nuclear radius was calculated. The average total cross section was then computed using the optical model for a square well potential. (UK)

## Nuclear Properties and Reactions, 190 ≤ A ≤ 219

*Refer also to abstracts 23525, 23532, 23553, 23564, 23579, 23583, 23590, and 23617.*

**23592** HYPERFINE STRUCTURE ANALYSIS FOR THE GROUND CONFIGURATION OF BISMUTH. Rosen, A. (Chalmers Tekniska Hoegskola, Goteborg). Phys. Scr.; 6: No. 1, 37-46(1972).

An analysis of the magnetic and electric hyperfine structure has been performed for the $6p^3$ configuration of $^{209}$Bi by use of an effective hyperfine structure Hamiltonian. For the magnetic hyperfine structure, experimental mean values of $r^{-3}$ exist for the orbital, spin-dipole and spin terms of the Hamiltonian. Theoretical mean values of $r^{-3}$ obtained from relativistic self-consistent-field (SCF) wave functions are in good agreement with the experimental orbital and spin-dipole values of $(r^{-3})$, while relativistic effects can only explain about 50% of the experimental spin part. This discrepancy is mainly due to core polarization, which has been estimated by use of nonrelativistic unrestricted SCF wave functions. The core polarization contribution has been corrected for relativistic effects by using correction factors obtained from a comparison between relativistic and nonrelativistic restricted SCF wave functions. Most of the spin part of the hyperfine interaction can be explained in this way. By use of hyperfine radial integrals obtained from relativistic SCF wave functions the quadrupole and octupole moments have been evaluated with the result: Q = −0.46b (Sternheimer uncorrected) and Ω = 0.62(8) n.m.b., respectively. (auth)

**23593** NUCLEAR STRUCTURE STUDIES WITH AN INTERACTION DETERMINED FROM CONSERVATION LAWS. Nopre, Hugues (Centre de Recherches Nucleaires, Strasbourg); Werner, E. Z. Phys.; 257: No. 5, 410-423(1972).

A density-dependent contact force whose parameters are derived from the requirements of translational invariance and gauge invariance is applied to spectroscopic studies in $^{208}$Pb. It is shown that spectroscopic studies of states of natural parity and of electric multipole transitions yield no physically significant, additional information on force parameters compared to the translational invariance subsidiary condition. (1 figure, 6 tables) (auth)

## Nuclear Properties and Reactions, A ≥ 220

*Refer also to abstracts 22272, 22942−22944, 23524, 23525, 23532, 23568, 23590, and 23634.*

**23594** (AD-748643) ISOMERIC GAMMA RAYS FOR TIMES LESS THAN ONE MICROSECOND AFTER $^{235}$U(n,f) AND $^{239}$Pu(n,f). Final Report. Sund, R. E.; Verbinski, V. V.; Weber, H. (Gulf Radiation Technology, San Diego, Calif.). 15 Apr 1972. Contract DASA01-69-C-0059. 55p. (Gulf RT-A-12073; DNA-2899-F). NTIS.

Measurements of the isomeric gamma-ray energy spectra from the thermal-neutron fission of $^{235}$U and $^{239}$Pu were performed with a Ge(Li) detector for times between 20 ns and about 1 μs after fission. Sixty-nine resolved gamma-ray peaks with different energies and half-lives were observed; 36 of these gamma-ray peaks had not been seen in previous delayed gamma-ray measurements. The fission-fragment mass numbers for many of the gamma rays were determined by comparison of the gamma-ray energies and half-lives with the results of previous $^{252}$Cf measurements. Gamma rays which decay in cascade from the same isomeric state were identified on the basis of mass numbers, gamma-ray half-lives, and intensities. (auth)

**23595** (ANL-Trans−937) PRODUCTION OF SPONTANEOUSLY FISSIONING ISOMERS WITH NANOSECOND HALF-LIVES IN REACTIONS WITH α-PARTICLES. Gangrskii, Yu. P.; Nguyen Kong Khanh; Pulatov, D. D. (Joint Inst. for Nuclear Research, Dubna (USSR)). 14 Feb 1972. Translated from report JINR-Pu-6286. 13p. Dep. NTIS.

Targets of thorium, uranium, plutonium, and americium were irradiated with α particles at the isochronous cyclotron of the Laboratory of Nuclear Reactions of the Joint Institute for Nuclear Research. Spontaneously fissioning isomers of plutonium, curium, and berkelium with half-lives of $10^{-9}$ to $10^{-7}$ were produced. The time-of-flight method was used. The data obtained are discussed on the basis of the model of the double-humped fission barrier. (5 figures, 1 table) (auth)

**23596** (FOA−4−4505-A-2) FISSION CROSS SECTIONS: A REVIEW OF EXPERIMENTAL DATA. Stroemberg, L. G. (Forsvarets Forskiningsanstalt, Stockholm (Sweden)). Aug 1972. 23p. Dep. NTIS (U. S. Sales Only).

A review of experimental data for neutron-induced fission in the energy region 10 keV to 15 MeV is given in graphical form for the nuclei $^{233}$U, $^{235}$U, $^{238}$U, $^{239}$Pu, $^{240}$Pu and $^{241}$Pu. Evaluated data from the literature are given both in graphical and tabular form as comparison. (auth)

**23597** (FRNC-TH-236) STUDY OF THE DISTRIBUTION OF FISSION PRODUCTS BY ON-LINE ISOTOPIC SEPARATION. Bocquet, J. P. (Grenoble Univ. (France). 1971. 164p. (In French). NTIS (U. S. Sales Only).

Thesis.

The mass and charge distributions of rare gases (Xe and Kr) encountered in the fission of $^{233}$U, $^{235}$U, $^{238}$U and $^{232}$Th by 14-MeV neutrons were measured. An on-line isotopic separation method was used to analyze the products collected quantatively. The device used (reaction chamber, isotope separator, ion collection and activity detection equipment) is described. The behavior of the atoms and then the rare gas ions along the entire path conducting them from the grain of fissile material up to the Al ribbon in which the ions implant themselves was analyzed. Two parameters come into play: the geometry of the installation and the operation of the ion source. These parameters were measured experimentally, and their effect on the correction factors was studied from the equation developed for the system. This method enabled the cumulative yield and the independent yield of an element to be obtained. (FR)

**23598** (INR–1429) ENERGY–ANGULAR DISTRIBUTION OF $\alpha$ PARTICLES EMITTED IN FISSION OF $^{236}$U. Polar Emission. Piasecki, E. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 181p. Dep. NTIS (U. S. Sales Only).

Thesis.

Measurements were made of the energy–angular distribution of $\alpha$ particles emitted during the thermal-neutron fission of $^{235}$U. The FWHM of the angular distribution, after the extrapolation of the alpha particle energy spectra, was determined to be 20.5°. It was established that about 5 percent of all alphas emitted in fission are flying in the same direction as the fragments, and their energy is about 23 MeV. This phenomenon, referred to as "polar emission," can be partly described by the in-flight evaporation from the excited fission fragments; some puzzling effects remain, however, unexplained. Suggestions as to further experiments and of exploiting this phenomenon are given. (58 figures, 8 tables, 126 references) (auth)

**23599** (JINR–P7-6815) DIRECT REACTIONS IN $^{22}$Ne–$^{232}$Th INTERACTION. Artyukh, A. G.; Vil'chinski, Ya.; Volkov, V. V.; Gridnev, G. F.; Mikheev, V. L. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Reactions). 1972. 15p. (In Russian). Dep. NTIS (U. S. Sales Only).

$^{232}$Th was bombarded with $^{22}$Ne ions of 174 MeV energy. Angular distributions, energy spectra, and cross sections of direct-reaction products with $3 \leq Z \leq 12$ were obtained using the $\Delta E-E$ method. (4 figures, 2 tables) (auth)

**23600** (JUL-887-PC) CORA: A PROGRAM FOR CALCULATION OF ISOTOPE FORMATION BY REACTOR IRRADIATION UNDER CHANGING NEUTRON FLUX CONDITIONS. Kurz, U.; Michael, H. (Kernforschungsanlage, Juelich (West Germany). Institut Fuer Physikalische Chemie). Sep 1972. 54p. (In German). Dep. NTIS (U. S. Sales Only).

A computer program, written in Fortran IV, is described for calculating both formation and destruction of nuclides through neutron absorption and radioactive decay. The nuclides may form reaction series with up to 10 successive members. The effect of changes in neutron flux and shut-downs of the neutron source (reactor) on the relative distribution of nuclides in the mixture is taken into account. At the start of irradiation, the sample may contain either a single nuclide or an arbitrary mixture of nuclides belonging to the series under computation. Application of the computer program is illustrated by a practical example. (1 figure, 1 table) (tr-auth)

**23601** (ORNL-TM–3696) SIMULTANEOUS MEASUREMENTS OF THE NEUTRON FISSION AND CAPTURE CROSS SECTIONS FOR $^{235}$U FOR NEUTRON ENERGIES FROM 8 eV TO 10 keV. Perez, R. B.; de Saussure, G.; Silver, E. G.; Ingle, R. W.; Weaver, H. (Oak Ridge National Lab., Tenn.). Dec 1972. Contract W-7405-eng-26. 91p. Dep. NTIS.

Simultaneous measurements of the neutron fission and capture cross sections of $^{235}$U were performed at the Oak Ridge Electron Linear Accelerator (ORELA) for neutrons with energies between 8 eV and 10 keV. These cross sections were measured relative to the standard $^{10}$B(n,$\alpha$) reaction cross section. The comparison of the present $^{235}$U capture cross section with the values from other available sources shows that below 200 eV there is general agreement within an error band of ±5%. In the keV energy region, the average difference observed rises to ±12%. The fission cross section results presented here agree with a world-wide compilation of fission data typically within a 3% error in the entire range of neutron energies investigated in this work. The values of alpha, capture-to-fission ratio, exhibit a remarkable amount of structure superimposed on the featureless behavior predicted by Bohr's fission channel theory. (29 figures, 17 tables) (auth)

**23602** (ORNL-TM–4059) MEASUREMENT OF THE $^{238}$U CAPTURE CROSS SECTION FOR INCIDENT NEUTRON ENERGIES UP TO 100 keV. de Saussure, G.; Silver, E. G.; Perez, R. B.; Ingle, R.; Weaver, H. (Oak Ridge National Lab., Tenn.). Feb 1973. Contract W-7405-eng-26. 122p. Dep. NTIS.

The neutron-capture cross section of $^{238}$U was measured for incident neutron energies between 5 eV and 100 keV by using a pulsed electron linac neutron source and the time-of-flight technique. Capture gamma rays were detected by a large liquid scintillator located on a 40-m flight path. The incident neutron flux was monitored by a $^{10}$BF$_3$ ionization chamber. The cross section was normalized by the saturated resonance technique. A brief description of the experimental technique and a discussion of the results are given. A complete tabulation of one of the measurements is included. (auth)

**23603** FRAGMENT MASS RATIOS IN $^{252}$Cf FISSION VERSUS PROMPT GAMMA RAY ENERGY. Brooks, J. W. Jr. Irvine, CA; Univ. of California (1972). 80p. University Microfilms Order No. 72-32,338.

Thesis (Ph. D.).

Gamma rays associated with the spontaneous fission of $^{252}$Cf were observed in the energy range 10 to 16 MeV by using two 3-in. × 11.5-in. dia NaI(Tl) crystals in coincidence with two solid state fission counters. Evidence is presented for a gamma-ray multiplicity of 2. This implies the presence of a collective mode of fragment de-excitation. The fission-fragment mass-ratio distribution shows an increase in the number of symmetric fissions when the detected gamma energy exceeds 14 MeV. Corrections were made for the background due to gammas arising from the capture of fission neutrons. (Diss. Abstr. Int. B)

**23604** DECAY OF $^{234\,m}$Pa(UX$_2$). Marsol, C.; Ardisson, G. (Univ., Algiers). Radiochem. Radioanal. Lett.; 13: No. 2, 109-116 (5 Mar 1973). (In French).

The decay characteristics of $^{234\,m}$Pa were investigated with the aid of a Ge(Li) spectrometer. Radiochemical separations of Pa/Th were performed each 15 min in order to eliminate UZ contribution. 95 $\gamma$ rays are reported, 63 of which are new. A new $^{234}$U level scheme is suggested on the basis of these results. (2 figures, 1 table) (auth)

**23605** THERMAL NEUTRON FISSION CROSS SECTIONS IN THE RANGE $302 \geq A \geq 223$. McMinn, John (Kernforschungsanlage, Juelich, Ger.). Z. Phys.; 257: No. 5, 389-401(1972).

A least-squares method is used to fit a smooth curve to known thermal-neutron fission cross section data for nuclei of even N. By making use of fission barriers resulting from a modified liquid-drop formalism coupled with the Strutinsky normalization procedure, the result is generalized and applied to the prediction within this framework of some 59 cross sections in the actinide and adjacent subactinide and transactinide regions, as well as to the prediction of an additional 37 cross sections in the superheavy region. In the first group is included a number of nuclides for which presently available cross section data are necessarily cited as upper limits. In the second group, interest is focused on the predicted island of stability surrounding a neutron shell closure at 184 and a proton shell closure at 114. The results, while they are regarded as plausible estimates and not precise determinations, indicate that many cross sections in this region can be expected to undergo a pronounced reduction in magnitude relative to the limited number of estimates previously given in the literature. (4 figures, 3 tables) (auth)

**23606** PRESENT STATUS IN SUPER-HEAVY ELEMENT CALCULATIONS. Nilsson, S. G.; Damgaard, J. (Tekniska Hoegskolan, Lund, Sweden). Phys. Scr.; 6: No. 2-3, 81-93(1972).

The theoretical work done in predicting a possible island of super-heavy elements with masses centered around A about 300, or about 15% in excess of the heaviest elements presently synthesized, is reviewed. Both the Hartree–Fock and the single-particle shell model approaches are discussed, with particular emphasis on the latter. The convergence in predictions of independent theoretical research groups is noted. (auth)

**23607** CROSS SECTION FOR $^{228}$Th FISSION BY NEUTRONS. Vorotnikov, P. E.; Gladkikh, G. S.; Davydov, A. V.; Dubrovina, S. M.; Otroshchenko, G. A.; Pal'shin, E. S.; Shigin, V. A.; Shubko, V. M. (Inst. of Atomic Energy, Moscow). Yadern. Fiz.; 16: No. 5, 916-918(1972). (In Russian).

The results on measuring cross sections for $^{228}$Th fission by neutrons in the energy range 0.16–1.7 MeV and 5 MeV are presented. Use was made of glass detectors for recording the fragments. The cross section is of a threshold character. Fission threshold is 1.0 MeV. Fission cross section for $^{228}$Th at the plateau is 0.18 barn. In the cross section development the maximum is observed at energies 0.50, 1.07, and 1.63 MeV. (auth)

**23608** FISSION BARRIERS FOR ODD NUCLEI. Adeev, G. D.; Cherdantsev, P. A. (Tomsk Polytechnic Inst., USSR). Yadern. Fiz.; 16: No. 5, 919-925(1972). (In Russian).

The Strutinsky method is used to calculate potential deformation energy of odd nucleus. The energy surface for a number of fissioning odd and odd-odd nuclei has been derived as the function of fission and asymmetrical coordinates. The energy surface structures of the odd and adjacent even-even nuclei are identical. The fission barrier heights of odd nuclei is systematically larger than those of adjacent even-even nuclei. (auth)

**23609** INDEPENDENT ISOMERIC YIELD RATIO OF $^{148}$Pm IN THE THERMAL-NEUTRON INDUCED FISSION OF $^{233}$U. Umezawa, H. (Japan Atomic Energy Research Inst., Tokai). J. Inorg. Nucl. Chem.; 35: No. 2, 353-359(Feb 1973).

Fractional independent yields of 41.3-d $^{148m}$Pm($6^-$) and 5.37-d $^{148g}$Pm($1^-$) have been determined in the thermal-neutron induced fission of $^{233}$U by radiochemical techniques. Calculation based on a statistical theory of the spin distribution of the primary fragment has been made for the isomer ratio. A value of mean angular momentum of the primary fragment, $\bar{J} = 8.3 \pm 2.0\ \hbar$, was obtained by comparing the experimental isomer ratio, $\sigma_m/(\sigma_m + \sigma_g) = 0.80 \pm 0.06$, with the calculated values. The magnitude of the fragment angular momentum agreed well with a predicted value resulting from calculation based on the statistical model using the fragment excitation energy which has been estimated from the experimental data of the prompt neutron and gamma-ray emissions. (auth)

## Nuclear Theory

*Refer also to abstracts 23242, 23307, 23405, 23516, 23563, and 23608.*

**23610** (COO-3001-28) ALPHA-PARTICLE SPECTROSCOPIC AMPLITUDES AND THE SU(3) MODEL. Ichimura, M.; Arima, A.; Halbert, E. C.; Terasawa, T. (State Univ. of New York, Stony Brook. Dept. of Physics). 1972. Contract AT(11-1)-3001. 100p. Dep. NTIS.

Formulas for calculating spectroscopic amplitudes for emission or transfer of $\alpha$ particles are developed in the framework of the harmonic-oscillator shell model with SU(3) classification. These formulas are applied to some interesting states of $^{20}$Ne, e.g., low-lying $(sd)^4$ shell-model states, members of the lowest $K = 0^-$ band with SU(3) label (90), and $2\hbar\omega$-excited states with SU(3) label (10.0). Spurious center-of-mass motion is removed. The formulas are also applied to the ground and some excited states of $^{16}$O. The $^{16}$O wave functions of Brown and Green are used in an investigation of how the mixing among 0p–0h, 2p–2h, and 4p–4h states affects the wave function for relative motion between the $\alpha$ cluster and the mass-12 nucleus. These calculations indicate much larger $\alpha$ reduced widths for states which are mainly 4p–4h than for states which are mainly 0p–0h or 2p–2h. Spectroscopic amplitudes are also calculated for some $^{16}$O and $^{12}$C states described as linear chains of $\alpha$ particles. (2 figures, 12 tables, 61 references) (auth)

**23611** (INP-806, pp 87-113) COHERENT NUCLEAR PRODUCTION OF CONTINUUM STATES. Gottfried, K. (CERN, Geneva). 1972.

A formalism is described for coherent production of states lying in a broad mass continuum in nucleon reactions with nuclei. This formalism is a fairly straightforward generalization of that of Van Hove designed to include the minimum momentum transfer and strong overall coupling between the nucleon and the N* continuum. The propagation of a mass continuum in nuclear matter and Van Hove's model are discussed. (JFP)

**23612** (INR-P-1427) SPIN AND SPIN–ISOSPIN SYMMETRY ENERGY OF NUCLEAR MATTER. Dabrowski, J.; Haensel, P. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 30p. Dep. NTIS (U. S. Sales Only) $3.50.

The expression, $E/A = \epsilon_{vol} + \frac{1}{2}\epsilon_\tau\alpha_\tau^2 + \frac{1}{2}\epsilon_\sigma(\alpha_n + \alpha_p)^2 + \frac{1}{2}\epsilon_{\sigma\tau}(\alpha_n - \alpha_p)^2$, for the ground-state energy of nuclear matter with an excess of neutrons, of spin-up neutrons, and of spin-up protons (characterized by the corresponding parameters, $\alpha_\tau = (N - Z)/A$, $\alpha_n = (N\uparrow - N\downarrow)/A$, and $\alpha_p = (Z\uparrow - Z\downarrow)/A$) contains three symmetry energies: the isospin symmetry energy, $\epsilon_\tau$, the spin symmetry energy, $\epsilon_\sigma$, and the spin–isospin symmetry energy, $\epsilon_{\sigma\tau}$. General expressions for $\epsilon_\sigma$ and $\epsilon_{\sigma\tau}$ are obtained with the help of the K matrix which depends on four different Fermi momenta. With suitable approximations, numerical values of $\epsilon_\sigma$ and $\epsilon_{\sigma\tau}$ (and also of $\epsilon_\tau$) are obtained with the help of the Brueckner–Gammel–Thaler, the Hamada–Johnston, and the Reid soft-core nucleon–nucleon potentials. The most reliable results, obtained with the Reid soft-core potential, are $\epsilon_\tau = 61$ MeV, $\epsilon_\sigma = 74$ MeV, $\epsilon_{\sigma\tau} = 73$ MeV. The possibility of estimating the energies of the spin and spin–isospin modes of collective nuclear excitations is discussed. (2 tables) (auth)

**23613** (INR-P-1438) SPIN AND ISOSPIN DEPENDENCE OF THE SINGLE-PARTICLE POTENTIAL IN NUCLEAR MATTER. Dabrowski, J.; Haensel, P. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 12p. Dep. NTIS (U. S. Sales Only) $3.00.

The spin- and isospin-dependent parts of the single-particle potential in nuclear matter are calculated at the Fermi surface with the Brueckner–Gammel–Thaler and the Reid soft-core potentials. The spin–spin part of the optical-model potential is estimated. The rearrangement effects turn out to be very important. (2 tables) (auth)

**23614** (JINR-E6-6870) FINE STRUCTURE IN DELAYED PROTON SPECTRA. Karnaukhov, V. A.; Bogdanov, D. D.; Petrov, L. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1972. 18p. Dep. NTIS (U. S. Sales Only) $3.00.

The fine structure in delayed-proton spectra is interpreted on the basis of statistical fluctuations associated with the variation of matrix elements for $\beta^+$ transitions and the relative proton widths of the excited states. Formulas are derived which give the variance of relative proton intensity in terms of the average characteristics of the delayed proton emission and the level density. The experimental data on the variance of the relative proton intensity for $^{111}$Te and the calculations performed using these formulas are in satisfactory agreement. The fluctuations predicted for $^{109}$Te considerably exceed the measured ones. (6 figures) (auth)

**23615** (JINR–P4-6832) STUDY OF THE DEFORMED NUCLEUS STRUCTURE IN (n,$\alpha$) REACTIONS. ($E_n$ = 14 MeV). Kozlovski, M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1972. 16p. (In Russian). Dep. NTIS (U. S. Sales Only).

The structure of deformed nuclear states in (n,$\alpha$) reactions is discussed. In the accepted model of these reactions that part is separated which is dependent on the structure of the nuclear wave functions. A simple model is applied for description of the states of the final nucleus. The calculations are compared with experimental data for (n,$\alpha$) cross sections. (8 figures) (auth)

**23616** (JINR–P4-6886) DYNAMIC DEFORMATION EFFECTS IN COMPOUND NUCLEUS INTERACTION. Permyakov, V. P. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1973. 15p. (In Russian). Dep. NTIS (U. S. Sales Only).

The reasons for variations in the values of the strong-interaction effective range, which are obtained from the analysis of differential cross sections for compound-nucleus elastic scattering are discussed. The behavior of the effective range, obtained on the basis of the analysis of experimental data, can be explained if one takes into consideration the possible onset of dynamic deformation. (3 figures) (auth)

**23617** (RLO–1388-630) FISSION BARRIERS FOR MEDIUM HEAVY NUCLEI. Mosel, U. Apr 1972. 62p. Dep. NTIS $5.25.

Potential-energy surfaces were calculated for the mass range $180 \leq A \leq 212$ by using the shell-correction method on the basis of a symmetric two-center shell model. All calculations were performed both with a constant and with a surface-dependent pairing strength. The results show that the fission barriers calculated with the latter prescriptions are incompatible with experimental data. The calculations for a constant pairing strength, however, in which the shells at the saddle are calculated on the same basis as those at the ground state, agree reasonably well with experimental data of the Berkeley group. The shell corrections for these nuclei are analyzed separately in detail and are found to exhibit remarkable regular structures, which can be explained by an interplay between the shells of the fragments and those of the fissioning nucleus. Finally, the existence of shape isomeric states and the treatment of the zero-point energy in these calculations are discussed. (13 figures, 3 tables) (auth)

**23618** SEARCH FOR A COUPLING SCHEME IN HEAVY DEFORMED NUCLEI: THE PSEUDO SU(3) MODEL. Ratna Raju, R. D.; Draayer, J. P.; Hecht, K. T. (Univ. of Michigan, Ann Arbor). Nucl. Phys.; A202: No. 3, 433-466(1973).

To test the possible usefulness of the pseudo SU(3) coupling scheme a few nuclear properties are examined which can be expected to be governed largely by the ($1g_{7/2}\,2d_{5/2}\,2d_{3/2}\,3s_{1/2}$) part of the proton configuration for odd-Z nuclei and the ($1h_{9/2}\,2f_{7/2}\,2f_{5/2}\,3p_{3/2}\,3p_{1/2}$) part of the neutron configuration for odd-N nuclei. The equivalence between these configurations and pseudo oscillator shells ($\tilde{f}_{7/2}\,\tilde{f}_{5/2}\,\tilde{p}_{3/2}\,\tilde{p}_{1/2}$) and ($\tilde{g}_{9/2}\,\tilde{g}_{7/2}\,\tilde{d}_{5/2}\,\tilde{d}_{3/2}\,\tilde{s}_{1/2}$) is exploited to show that the low-lying natural-parity rotational bands in deformed nuclei can be described approximately by many-particle states which are coupled to leading pseudo SU(3) representation (maximum possible value of $2\tilde{\lambda} + \tilde{\mu}$) of these configurations. The simple model in which the natural-parity part of the proton and neutron configurations are coupled to leading pseudo SU(3) representation predicts ground state magnetic moments in remarkably good agreement with experiment. The strong hindrance factors observed in certain interband M1 transition probabilities are, however, not predicted by this model. The diagonalization of a simple effective interaction within the leading pseudo SU(3) representation leads to spectra with the experimentally observed ordering of the K-bands. (The case of the Eu and Tm isotopes has been examined in some detail since these are expected to have leading pseudo SU(3) representations with the same quantum numbers $(\tilde{\lambda}\tilde{\mu})$ but with quite different ordering of the K-bands).

**23619** INFINITESIMAL TRANSFORMATION FOR HYPERSPHERICAL FUNCTIONS AND MOSHINSKY COEFFICIENTS. Raynal, J. (CEN de Saclay, Gif-sur-Yvette, France). Nucl. Phys.; A202: No. 3, 631-640(1973).

In order to obtain coefficients for a finite transformation (such as a change of basis for hyperspherical functions) the matrix of an infinitesimal transformation is written in a pseudo-diagonal form by means of sets of homogeneous linear equations. (auth)

**23620** RESONANCES AND ECHOES IN THE COMPLEX-ANGULAR MOMENTUM PLANE. Viano, G. A. (Univ., Genoa). Lett. Nuovo Cim.; 6: No. 7, 257-262(17 Feb 1973).

The complex-angular-momentum plane technique is examined for the following questions: description of a complex-angular-momentum model of the resonance; the rotational sequence of nuclear resonances and the corresponding pole trajectories; the role of the antiresonances or echoes; and the relations which exist among the Levison theorem, the rising trajectories, and the echoes. Some particular physical situations are discussed. (LBS)

**23621** PARITY-VIOLATING NUCLEAR INTERACTIONS AND MODELS OF THE WEAK HAMILTONIAN. Fischbach, E. (Purdue Univ., Lafayette, IN); Tadic, D. Phys. Rep.; 6C: No. 2, 123-186(Jan 1973).

The derivation of the parity-violating internucleon one-meson-exchange potentials is presented, stressing their connection with models of the weak interactions. Relevant problems concerning second class currents, gauge invariance, off-mass-shell effects, symmetry breaking and multimeson exchanges are discussed. An extensive bibliography of existing literature is also presented. (auth)

**23622** SINGLE-PARTICLE MODEL CALCULATIONS FOR DEFORMED NUCLEI OF SPHEROIDAL AND NON-SPHEROIDAL SHAPES. Ehrling, G.; Wahlborn, S. (Kungliga Tekniska Hoegskolan, Stockholm). Phys. Scr.; 6: No. 2-3, 94-108(1972).

A single-particle model for non-spherical nuclei with a local diffuse potential having spheroidal and non-spheroidal shapes is studied. The dependence of energy eigenvalues, Coriolis matrix elements and some related quantities on various parameters of the model is investigated. The values of the potential parameters, as well as the questions of the $\Delta N = 2$ mixing and the centrifugal interaction between particles in the rotor model, are discussed. (auth)

**23623** DISTORTION EFFECTS IN (p,2p) REACTIONS AT MEDIUM ENERGIES USING APPROXIMATE DISTORTED WAVES. Chatterjee, A. K. Moscow, ID; Univ. of Idaho (1971). 131p. University Microfilms Order No. 72-30,486.

Thesis (Ph. D.).

The (p,2p) reaction is chosen as a probe for discerning three-body effects in nuclear matter. The many-body problem is first approximated to a quasi three-body problem, and the coplanar symmetric geometry is chosen for a description of the problem for reasons of analytical simplicity. The distorted-wave t-matrix approximation is then applied in the static limit. Since the triplet cross section is a result of distortion, it is used to determine the extent of distortion described by the approximate distorted waves. It is found that approximate distorted waves, being similar to plane waves, do not adequately take into account the distortion present. The effects of local and nonlocal t matrices on the (p,2p) angular distributions are compared at 46 MeV for $^{14}$N target nuclei. It is observed that the magnitude of the cross section is lower for the nonlocal theory than for the local theory. The singlet cross section is extended to 175° for the first time, and the triplet cross section is also evaluated up to the same angle for (p,2p) reactions on $^{12}$C nuclei at 75 MeV. An asymmetry parameter is introduced to incorporate asymmetrical collisions in the theory. It appears that asymmetrical collisions in the (p,2p) reaction may be distorted enough in phase to give symmetrical protons in the final state. A phase technique is developed to acquire a better physical understanding of the interferences between components of matrix elements. It is found that at larger angles focussing effects are imporatant and the phases add constructively. Large cross sections for extreme back-angle scattering appear due to overlap of the focal regions of all the protons. (Diss. Abstr. Int., B)

**23624** FORMULATION, AND INVESTIGATION IN A THREE-BODY MODEL, OF AN EXACT DISTORTED WAVE APPROXIMATION FOR DEUTERON STRIPPING. Bouldin, D. P. Providence, RI; Brown Univ. (1972). 141p. University Microfilms Order No. 73-2235.

Thesis (Ph.D.).

A modified form of the distorted-wave Born approximation (DWBA) for deuteron stripping based on the approximation that the interaction between the proton and neutron in the deuteron can be represented by a one-term separable potential is proposed. Due to the projection-operator property of the separable interaction, the replacement of the deuteron three-body state by a product of two-body states, one describing scattering of the deuteron center of mass and the other representing the undistorted deuteron bound state, can be made in the new DWBA without approximation. The relationship between the new and standard formulations of the DWBA is studied extensively in a three-body, S-wave separable-interaction model. The new DWBA includes effects of deuteron distortion of the deuteron center-of-mass scattering state, whereas the old DWBA does not. Two-body scattering equations for the respective center-of-mass states are derived, and it is shown that asymptotically these states are equal. Calculations are presented which compare in the three-body model the coordinate-space representations of the two center-of-mass states. The applicability of the new DWBA to realistic situations is discussed. (Diss. Abstr. Int., B) (RWR)

**23625** ROTATIONAL INVARIANCE, INERTIA MOMENTS, AND $1^+$ STATES IN DEFORMED NUCLEI. Pyatov, N. I.; Chernei, M. I. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 16: No. 5, 931-940(1972). (In Russian).

With the help of the Marshalek and Weneser method there is reconstructed in boson approximation rotational invariance of Hamiltonians, used to describe deformed nuclei. General equations, connecting one particle matrix elements of the angular momentum operator and multipole operator of effective interactions (restoring rotational invariance) have been obtained. They are valid for any average field and are invariant with respect to insertion of residual interactions. A relation between the inertia moment of the system and properties of $1^+$-excitations has been established. (auth)

**23626** ACCOUNT FOR NUCLEON CORRELATIONS IN THE GLAUBER PICTURE OF HIGH ENERGY PARTICLE SCATTERING ON NUCLEI. Starodubskii, V. E. (Inst. of Nuclear Physics, Leningrad). Yadern. Fiz.; 16: No. 5, 946-957(1972). (In Russian).

In the framework of the Glauber multiparticle scattering theory there is studied a problem of the role of nucleon correlations of a short radius in high-energy hadron scattering on nuclei with $A \gg 1$. Such quantities as angular distribution of elastic scattering, total cross section, optical potential, etc. are considered. Correlations are introduced into all the orders in the two-particle amplitude in the model, that corresponds to the specificity of high energy scattering. The correlation effect in the values of calculated cross sections, in optical potential is studied depending on the correlation radius. (auth)

**23627** GRAND-CANONICAL FORMULATION OF RENORMALIZED CLUSTER EXPANSIONS FOR THE NUCLEAR-MATTER PROBLEM. Krotscheck, E. (Univ., Cologne); Nitsch, J.; Ristig, M. L.; Clark, J. W. Lett. Nuovo Cim.; 6: No. 4, 143-147(27 Jan 1973).

A suitable partial summation of the Iwamoto—Yamada (IY) cluster expansion is being sought. The IY expansion is designed for evaluation of the expectation value of the energy (or other observable) of nuclear matter, with respect to a correlated wave function. Various possible renormalizations can be discovered through detailed examination of the structure of the IY expansion or its "factorized" version. This paper discusses a special class of renormalizations distinguished by their structural relation to the grand-canonical formalism for classical imperfect fluids. The work proceeds from a known method for a general renormalization procedure in the context of the method of correlated basis functions. (RWR)

**23628** NUMERICAL STUDY OF RENORMALIZED JASTROW THEORY. Krotscheck, E. (Univ., Cologne); Nitsch, J.; Ristig, M. L.; Clark, J. W. Lett. Nuovo Cim.; 6: No. 4, 148-151(27 Jan 1973).

The grand-canonical derivation of a renormalized cluster expansion for the correlated expectation value of the ground-state energy of a homogeneous medium like nuclear matter has already been outlined (Lett. Nuovo Cim.; 6: No. 4, 143-147(27 Jan 1973)). The results of some numerical calculations based on the renormalized theory are presented here. Two simplified potential models are considered; they are intended to bracket the physical situation. Unrenormalized and renormalized energy results are tabulated for the two potentials. The quasi-classical approximation is found to be truly an excellent one. From these examples in the Jastrow context it appears that the original, unrenormalized Iwamoto–Yamada expansion (analogous to a classical virial expansion) is preferable to the renormalized one (analogous to a classical activity expansion). Whether the practicable superiority of unrenormalized over renormalized expansion persists in higher orders must be decided by future study. (2 tables) (RWR)

**23629** THREE-BODY MODEL FOR THE STUDY OF RESONANCE PHENOMENA. III. Beregi, P. (Joint Inst. for Nuclear Research, Dubna, USSR). Z. Phys.; 257: No. 5, 440-447(1972).

The potential and quasi-compound resonances appearing in a model three-body system consisting of two identical light particles and an infinitely heavy one is investigated by solving the Faddeev equations for negative total energy. (7 figures, 3 tables) (auth)

**23630** COMPUTATION OF CROSS SECTIONS AND POLARIZATIONS FOR NUCLEAR REACTIONS, IN WHICH ONLY SPIN $\frac{1}{2}$ PARTICLES ARE INVOLVED. Heiss, P. (Univ., Cologne). Comput. Phys. Commun.; 4: No. 3, 371-376(Dec 1972).

Both for a phase shift analysis and for reaction calculations one needs to relate cross sections, polarization values, etc., on the one hand and S-matrix elements in the usual lsJ representation on the other. For general cases this calculation requires great computational effort. For reactions in which only spin $\frac{1}{2}$ particles are involved this effort can be considerably reduced, by the explicit calculation of the M-matrix. Relatively simple relations between S-matrix elements and M-matrix elements are derived. From M-matrix elements, cross sections and polarizations are obtained in a simple way. Hence, the program requires only a small amount of high-speed storage space and runs relatively fast. (WDM)

**23631** ELASTIC CHANNEL CONTRIBUTIONS FROM PARTICLE TRANSFER BETWEEN HEAVY IONS. McMahan, C. A.; Tobocman, W. (Case Western Reserve Univ., Cleveland). Nucl. Phys.; A202: No. 3, 561-578(1973).

In certain nuclear collisions it is possible for particle transfer processes to occur for which the reaction products are indistinguishable from the initial participants in the collisions. In such cases the amplitude for the transfer process is a coherent addition to the optical model elastic amplitude. We use DWBA analysis to calculate the transfer matrix element. Two methods for combining the DWBA transfer and optical model elastic amplitudes are compared. The first method treats the transfer matrix element as the cross channel element of the K-matrix while the second uses it as the cross channel element of the T-matrix. The K-matrix approach includes in some measure the effects of repeated transfer processes. We calculated elastic scattering angular distributions for several nuclei at energies slightly above the Coulomb barrier and find that this method does reproduce the observed structure at backward angles. Our results indicate that for these cases only single transfer is important. (auth)

**23632** DOUBLE BETA DECAY. Fiorini, E. (Univ., Milan). pp 99-120 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on Neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

The detection of double beta decay by indirect and direct methods is considered in some detail and it is concluded that while experiments have been pushed to the limits of technical feasibility, theoretical calculations could be much improved to take advantage of the impressive limits of many experiments. (WDM)

**23633** NUCLEAR BETA-DECAY EXPERIMENTS AND SECOND-CLASS WEAK CURRENT. Vatai, E. (Inst. of Nuclear Research, Debrecen, Hungary). pp 261-267 of Neutrino '72. Vol. I. Frenkel, A. (ed.). Budapest; OMKDK-Technoinform (1972).

From Symposium on neutrino 1972; Balatonfuered, Hungary (11 Jun 1972). See CONF-720651-(Vol.1).

Experimental results on $\beta$-decay probabilities connected with the question of second-class currents are discussed. (auth)

**23634** SHELL MODEL AND ITS APPLICATION TO THE DEFORMATION ENERGY OF HEAVY NUCLEI. Pauli, H. C. (Univ., Basel). Phys. Rep.; 7C: No. 2, 35-100(Mar 1973).

The technical realization of the shell model with arbitrary fields is presented in detail, with special emphasis on the unusual and large deformations of the nuclear shape as they may occur in the fission process. Methods for developing realistic parametrizations of the nuclear shape and the potential well and for determining the parameters of the average fields are discussed. Consideration is restricted to wells with a Woods–Saxon distribution in the radial coordinate. By means of Strutinsky's shell-correction approach, the single-particle energies serve to calculate the potential part of a collective Hamiltonian. Its behavior with varying deformation is discussed both qualitatively and quantitatively. Considered are the deformation types of elongation, necking, reflection, and axial asymmetry of the nuclear shape. Evidence is given for geometrical symmetries which can be correlated to normal modes in finite nuclei. The transition from spherical to deformed nuclei is presented in detail for the radium isotopes; the importance of hexadecapole deformations is revealed. Finally, an extensive and systematic presentation of the energies and of the deformations at the various stationary points of the deformation energy is given for the nuclei in the actinide region and for the hypothetical superheavy nuclei. (34 figures, 3 tables, 114 references) (auth)

**23635** EXCITED STATES OF DEFORMED EVEN–EVEN ATOMIC NUCLEI. Karaev, R.; Sharipov, Sh. (Tashkent State Univ.). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 11, 19-24(1972). (In Russian).

A method is advanced for calculating the collective excited states of even–even nuclei such as the illustrative examples $^{154}$Gd, $^{156}$Gd, $^{160}$Dy, $^{168}$Er, $^{174}$Hf, and $^{188}$Pt. The basic formula depends on three parameters which were used in obtaining energy relations of excited states for deformed, spherical, and transition regions of nuclei. (KSW)

**23636** RELATIVISTIC KINEMATICS FOR TWO-BODY FINAL STATES. Braithwaite, W. J. (Univ. of Washington, Seattle). Comput. Phys. Commun.; 4: No. 2, 227-232(Nov 1972).

The computer program TWOBDY written in FORTRAN IV for the IBM 360/91 is described for calculating the relativistic kinematics for two-body final states in two-body reactions. (JFP)

**23637** RELATIVISTIC KINEMATICS FOR THREE-BODY FINAL STATES. Braithwaite, W. J. (Univ. of Washington, Seattle). Comput. Phys. Commun.; 4: No. 2, 233-238(Nov 1972).

The computer program BODY3 written in FORTRAN IV for the IBM 360/91 is described for the calculation of kinematically complete relativistic reaction kinematics for three-body final states using the principle of conservation of momentum–energy for an isolated system. (JFP)

**23638** NUCLEAR HARTREE–FOCK INTRINSIC WAVEFUNCTION PROJECTION PROGRAMS. Allard, J. (Institut d'Etudes Nucleaires, Algiers); Boumahrat, N.; Houssais, B.; Hassan, H. M.; Lambert, M. Comput. Phys. Commun.; 4: No. 2, 239-248(Nov 1972).

A computer program PROJ written in FORTRAN IV for the IBM 360/40 is described for the calculation of the energies of the rotational band generated by a nuclear wave function. The two-body interaction must be a sum of two gaussian potentials with arbitrary spin, isospin, and space-exchange terms. The geometrical basis includes the 1s, 1p, and 2s deformed shells. The program works with 40 occupied and unoccupied orbitals. The interaction must be exponential. (JFP)

**23639** ENERGY LEVEL CALCULATIONS WITH AROVMI MODEL. Abecasis, S. M.; Femenia, F. R. (Univ., of Buenos Aires). Comput. Phys. Commun.; 4: No. 2, 262-267(Nov 1972).

The computer program AROVMI written in FORTRAN IV for the IBM 360/50 computer is described for energy levels and ratios for rotational bands built on the ground state and $\gamma$ vibrational states in the AROVMI model. (JFP)

**23640** PEAK FUNCTIONS FOR A THREE-NUCLEON SYSTEM. Blokhintsev, L. D.; Shvarts, I. A. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; 13: No. 5, 523-530(1972). (In Russian).

Numerical calculations were made for the peak functions corresponding to the virtual processes $^{3}$H($^{3}$He) $\rightarrow$ d + n(p), and the properties of the processes were investigated. Various expressions for these peak functions were compared. Peak constants for the processes $^{3}$H ($^{3}$He) $\rightarrow$ d + n(p) were found, which were values of the peak functions on the mass surface and which play an important role in diagram and dispersion approaches to a description of nuclear reactions. (tr-auth)

**23641** MAGNETIC MOMENTS OF HIGHLY EXCITED STATES OF ATOMIC NUCLEI. Voronov, V. V.; Solov'ev, V. G. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz.; 16: No. 6, 1188-1194(1972). (In Russian).

On the basis of semimicroscopic approach there are obtained formulas for magnetic moments of highly excited states. It is shown, that magnetic moments are expressed via all the components of the wave functions of highly excited states. In accordance with the rough estimation the values of the magnetic moments of the states of intermediate excitation energy and highly excited states, neutron resonance included, should be equal in the order of magnitude to single-particle values. The situation with magnetic moments considerably differs from that with probabilities of E1- and M1-transitions from highly excited states to the lower ones, which $10^5-10^7$ times smaller than single-particle values. Theoretical results agree with the available experimental data on neutron resonance magnetic moments. (auth)

# PHYSICS (PLASMA AND THERMONUCLEAR)

## Confinement and Heating

*Refer also to abstracts 22556, 23500, and 23501.*

**23642** (EURFNR-1052) INTEGRATED DESIGN AND OPTIMIZATION OF SODIUM/SODIUM HEAT EXCHANGERS WITH COMPUTER ASSISTANCE. Schnauder, H. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). Oct 1972. 29p. (CONF-720849 2; KFK-1628). Dep. NTIS (U.S. Sales Only).

From Recent Developments in Heat Exchangers Seminar; Trogir, Yugoslavia (30 Aug 1972).

Work performed under United States—Euratom Fast Reactor Exchange Program.

The SINEX code allows the design of sodium/sodium intermediate heat exchangers for steady-state reference operation. The novel feature of the program system consists in the combination of thermal and mechanical calculations. A graphical output has been incorporated. A simplified cross section of each heat exchanger calculated can be plotted. In parameter calculations the influence of the different parameters can also be plotted automatically in diagrams. As an example of the application of the program system, sodium/sodium intermediate heat exchangers, made out of three different grades of austenitic steel, are compared with each other in terms of cost. (auth)

**23643** (IPP—2/201) ELEVATED ION TEMPERATURE IN A DOUBLE ENDED Q-MACHINE. Brown, I. G. (Max-Planck-Institut Fuer Plasmaphysik, Garching (West Germany)). Nov 1971. 24p. Dep. NTIS (U. S. Sales Only) $3.25.

The perpendicular ion temperature of a barium plasma contained in a double-ended Q-machine was measured by a spectroscopic technique. When the plasma is "ion-rich," good agreement is found between the measured ion temperature and the hot-plate temperature, while in the "electron-rich" regime the ion temperature is elevated above the hot-plate temperature. The increased ion temperature can be well accounted for by the energy input through the acceleration of ions through the electron sheath and their consequent thermalization. (auth)

**23644** (LA—5167-MS) MULTIPASS SYSTEMS FOR $CO_2$ LASER PLASMA HEATING AND DIAGNOSTIC SCATTERING EXPERIMENTS. Humphries, S. Jr. (Los Alamos Scientific Lab., N. Mex.). Feb 1973. Contract W-7405-eng-36. 24p. Dep. NTIS $3.25.

The interaction between plasmas and the infrared radiation from $CO_2$ lasers has become of great interest because of possibilities for plasma heating and diagnostic scattering experiments. Calculations are presented on a laser—plasma system in which the plasma is located within a high-Q laser cavity, maximizing the useful radiation density. The stability of cavities with the inclusion of a cylindrical pinch plasma is investigated for propagation along and across the column. Conditions are given under which the presence of the plasma is necessary for cavity oscillations, raising the possibility of plasma Q-switching. Calculations are performed on the expected shape of laser modes in the plasma, taking the plasma dynamics into account. It is shown that these modes are unfavorable to heating of the bulk of the plasma, and are unstable against hydromagnetic kinking. A heating experiment using a small pinch and modest laboratory laser is described that would allow measurement of low-density ($10^{16}$ to $10^{17}$ cm$^{-3}$) laser—plasma interactions and many transport properties of fully ionized plasmas. Feasibility studies are also presented on the use of closed-cavity $CO_2$ laser scattering to measure the ion temperature in pinches. Experiments demonstrating the behavior of closed cavities in which powers of 200 MW were obtained with a 1-joule laser are also described. (auth)

**23645** (LPS-95) RF PLASMA HEATING IN THE THM-2 MIRROR MACHINE. Clark, R. W.; Swanson, D. G.; Korn, P.; Robertson, S.; Wharton, C. B. (Cornell Univ., Ithaca, N. Y. Lab. of Plasma Studies). Jun 1972. Contract AT(30-1)-3958. 7p. (CONF-720705-7). Dep. NTIS.

From 1st topical conference on rf plasma heating; Lubbock, Texas, USA (6 Jul 1972).

Following turbulent heating in the THM-2 mirror machine at Cornell University, 75 kW of rf power was coupled to the hydrogen plasma through an unshielded Stix coil. The plasma density was maintained at $10^{12}$ to $5 \times 10^{12}$ cm$^{-3}$ for the 600-μsec duration of the rf pulse, and neutral-energy-analyzer measurements indicate $T_i \sim$ 100 eV, while diamagnetic loop measurements yield $100 \lesssim T_e + T_i \lesssim 200$ eV. Measurements also indicate that the perpendicular energy of the plasma was proportional to the net rf power input with no observable saturation. In other experiments, short bursts of rf power were applied to the plasma by means of a charged capacitor designed to ring with the antenna inductance. In these experiments, probe measurements showed discrete changes in the amplitude of the rf signals near the harmonics of the ion cyclotron frequency, as well as a decrease in the antenna loading when $\omega < \Omega_i$. Harmonic generation of signals at twice the impressed frequency was also noted. (auth)

**23646** (MATT-955) RESULTS OF FM-1 SPHERATOR EXPERIMENTS AND POSSIBILITY OF ELECTRON-COIL FUSION REACTOR. Yoshikawa, S. (Princeton Univ., N. J. Plasma Physics Lab.). Jan 1973. Contract AT(11-1)-3073. 24p. (CONF-721132-2). Dep. NTIS $3.25.

From Plasma physics meeting of the American Physical Society; Monterey, California, USA (13 Nov 1972).

Experimental results of the FM-1 spherator experiments are reviewed. The important conclusions obtained so far are (1) that plasma confinement times are near classical if the plasma temperature is low enough for a fixed plasma density, (2) that the plasma confinement times are limited to 300 times the so-called Bohm time as the temperature increases, (3) plasma loss can be caused by several reasons, and (4) in particular, fluctuations which behave consistently with the theoretical prediction of trapped-particle instabilities appear to dominate the plasma-loss processes. This result, along with the recently developed experiments and theories on electron-coil systems, suggests that an electron-coil fusion reactor may be a possible fusion reactor of comparatively stable property and compactness in size. (auth)

**23647** PLASMA HEATING AND ACCELERATION DUE TO LANDAU DAMPING OF HYDROMAGNETIC WAVES. Barnes, A.; Hung, R. J. (Ames Research Center, Moffett Field, CA). J. Plasma Phys.; 8: No. 2, 197-215(Oct 1972).

Energy and momentum exchange associated with Landau damping of hydromagnetic waves are analysed from a macroscopic viewpoint and the conclusions compared with those of the resonant quasi-linear theory. It is found that the heating of protons and electrons is correctly given by the resonant theory, but that the momentum exchange is not correctly described by the resonant theory. (auth)

**23648** AVERAGED EQUATIONS OF CUMULATIVE LASER HEATING OF TWO-TEMPERATURE PLASMA IN A Z PINCH TAKING INTO ACCOUNT THE NUCLEAR FUSION ENERGY. Kaliski, S. (Inst. of Fundamental Technological Research, Warsaw). Bull. Acad. Pol. Sci., Ser. Sci. Tech.; 20: No. 7-8, 609-615(1972).

An additional cumulation effect consisting in concentric implosion of an external conducting envelope into plasma produces more intense plasma thermalization effects and increased recovery of nuclear fusion energy by increasing the cumulation effect of z-pinch and prolonging the period during which the expanding plasma is kept in its state of concentration. (auth)

**23649** AVERAGED EQUATIONS OF CUMULATIVE LASER HEATING OF PLASMA IN A Z PINCH WITH CONSIDERATION OF THE RECOVERY OF THE ENERGY OF NUCLEAR FUSION. Kaliski, S. (Inst. of Fundamental Technological Research, Warsaw). 20: No. 7-8, 599-607(1972).

The equations of the title are derived. In the laser heating of plasma in a z pinch, an additional cumulation effect was obtained by the concentric implosion of an external cylindrical conducting envelope into the plasma. This paper is confined to the case of one-temperature plasma. The construction and numerical analysis of solutions will be given separately for both one- and two-temperature plasma. (auth)

**23650** HEATING OF LASER-INDUCED PLASMAS IN HELIUM. Wang, C. C.; Davis, L. I. Jr. (Ford Motor Co., Dearborn, MI). Opt. Commun.; 7: No. 1, 61-64(Jan 1973).

Agreement of a qualitative nature is noted between experiments and published theoretical predictions. The possibility of an instability in the transfer of energy from the radiation field to the electrons in the breakdown region is pointed out. (auth)

**23651** ANOMALOUS ION HEATING IN A LASER-HEATED PLASMA. Bodner, S. E. (Univ. of California, Livermore); Chapline, G. F.; DeGroot, J. Plasma Phys.; 15: No. 1, 21-27 (Jan 1973).

Computer experiments and theoretical arguments suggest that ions in a laser-heated plasma can be heated directly by laser-induced plasma instabilities. This may explain the large neutron yields seen in some experiments involving the focusing of nanosecond laser pulses onto solid-deuterium targets. (auth)

**23652** PROPAGATION OF CHARGES AND CONFINING A DENSE PLASMA BY ELECTROMAGNETIC FIELDS. Raizer, Yu. P. (Inst. of Problem Mechanics, Moscow). Usp. Fiz. Nauk; 108: No. 3, 429-463(Nov 1972). (In Russian).

Charge propagation is discussed and an analogy to combustion is introduced in this review of plasma confinement. Shock waves, light "detonations," stabilized optical discharges confined by focused beams, high-frequency discharges in gas streams, propagation of a "flame" in a wave guide containing atmospheric air, discharge in a resonator, and plasma temperatures in an arc discharge constitute the major part of the discussion. Some attention is given to nonequilibrium regimes, e.g., ionization waves and discharge contraction in a constant field, ionization waves in wave guides, and "super-detonation" heat conductivity and radiation regimes. (55 references) (KSW)

## Diagnostics

*Refer also to abstracts 23204 and 23644.*

**23653** (CONF-720961-8) ELECTRON ENERGY DISTRIBUTIONS FROM SOFT X-RAY BREMSSTRAHLUNG. Eubank, H. (Princeton Univ., N. J. Plasma Physics Lab.). 1972. 11p. Dep. NTIS $3.00.

From Symposium on plasma heating and injection; Varenna, Italy (21 Sep 1972).

The spectra region considered is from 1 to 100 keV. Measurement techniques for this region are discussed. Some results are given from the use of semiconductor detectors applied to dc plasmas and long-duration pulsed plasmas. (MOW)

**23654** (CONF-720961-9) PLASMA MEASUREMENTS WITH PARTICLE BEAMS. Eubank, H. (Princeton Univ., N. J. Plasma Physics Lab.). 1972. 26p. Dep. NTIS $3.50.

From Symposium on plasma heating and injection; Varenna, Italy (21 Sep 1972).

A monoenergetic beam of atoms traversing a system of scattering centers is considered. The use of hydrogen atom beams to measure ion densities is described. The use of alkali metal beams to measure electron temperatures is also discussed. Data are given for several experiments. (MOW)

**23655** (IAE-2195) DEVELOPMENT OF A METHOD OF PROBING ELECTRIC AND MAGNETIC FIELDS IN A PLASMA WITH BEAMS OF CHARGED PARTICLES. Morozov, A. I.; Dauter, B. V.; Temchin, S. M. (Institut Atomnoi Energii, Moscow (USSR)). 1972. 34p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.75.

Some systematic questions associated with development of electric and magnetic field diagnostics with charged-particle beams are discussed. Previous theoretical and experimental work in this area is surveyed. (28 references) (tr-auth)

**23656** (INR-1442) MEASUREMENTS OF PLASMA DENSITY WITH LASER INTERFEROMETRY METHODS. Appelt, J.; Sadowski, M. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 64p. (In Polish). Dep. NTIS (U. S. Sales Only) $5.25.

The physical principles of interferometric methods used for plasma diagnostics are discussed, and the systems of conventional interferometers with laser sources and of laser three-mirror interferometers are presented. The laser interferometers designed and constructed in the Hot Plasma Physics Laboratory are described, and the results of preliminary investigations performed with those devices are given. A comparison of different interferometric methods is carried out, and various factors that influence the use of these methods are discussed. (auth)

**23657** (IPP-4/74) SERVO PLOTTING SYSTEM FOR THE DETERMINATION OF POTENTIAL FIELD DISTRIBUTION IN AN ELECTROLYTIC TANK. Werner, F. (Max-Planck-Institut fuer Plasmaphysik, Garching (West Germany)). Oct 1972. 46p. (In German). Dep. NTIS (U. S. Sales Only).

An ac servo control system with a three-probe array capable of automatically plotting potential-field distributions in an electrolytic tank is described. Directed by two servo drives, each operating along an axis of a rectangular co-ordinate system, the probe is moved at constant speed tangential to an equipotential line. Deviations from the rated potential are compensated in a direction normal to that of travel. The respective direction of the potential line is indicated by the two differential signals picked up with the three-probe sensor. These probe signals correspond to the components of the local field gradient in parallel to both axes of the co-ordinate system. The constant-speed drive control necessitates an elimination of the field-gradient magnitude so that just a true measure of the field direction remains. The same is done with the error signal from the bridge circuit before splitting it into the two-drive control components. All this, just as the final composition of the control voltages, is accomplished by analog computing operations. Some examples of potential analogs and field plots are given. (auth)

**23658** (LBL-1531) STUDY OF A BEAM-PLASMA INSTABILITY BY SPECTROSCOPIC METHODS. Hess, R. A. (California Univ., Berkeley. Lawrence Berkeley Lab.). Dec 1972. Contract W-7405-eng-48. 112p. Dep. NTIS $7.75.

Thesis.

Spectroscopic methods are used to study a beam-plasma system and in particular the electric fields produced by the beam-plasma instability. A 4-keV, 40-mA electron beam of diameter 1 mm is directed into a chamber containing He at 0.3 torr. An external magnetic field of up to 7600 G is present. The electron beam can be chopped for time-resolved measurements on the initial growth of the beam-plasma instability; the rise time of the beam is 10 nsec and the fall time is 100 nsec. Time-resolved measurements show that the electric field of the instability grows from noise level to near saturation within a time $\approx$25 nsec after the beam is turned on. The electric field is nearly entirely confined to the volume traversed by the electron beam, and has its maximum amplitude on the edge of the beam. The electric field is also strongly localized in the axial direction along the beam with a peak at a distance of 2 to 4 cm from where the beam enters the chamber. After saturation of the instability, the field has a maximum amplitude of about 2000 V/cm. The frequency of the electric field is measured to be near to 74 GHz and could be either the electron plasma frequency or the upper hybrid frequency within errors on knowledge of the density. The frequency spectrum of the electric field is found to be quite narrow; its relative bandwidth is $\lesssim$14%. Two different polarizations of the electric field are observed: In one case the electric field is polarized randomly in direction and, in another case, is polarized perpendicular to the magnetic field and random in azimuthal angle. The two different polarizations are observed for nearly the same beam and plasma parameters. These observations on the electric field are found to be generally consistent with the results of theoretical studies on the beam-plasma system. (auth)

**23659** (LRP-54/72) HIGH-POWER $CO_2$ TEA LASER STUDIES. Oettinger, P. (Centre de Recherches en Physique des Plasmas, Lausanne (Switzerland)). Aug. 1972. 25p. Dep. NTIS (U. S. Sales Only).

The need for a good interferometric and light-scattering plasma-diagnostic radiation source has resulted in a program to construct high-power, TEA, $CO_2$ lasers. A resistance-limited, 1.2-m long, pin-plate, plane-parallel oscillator, with a 4-cm electrode separation, has yielded maximum powers of 20 MW, energies approaching 2J, and electrical-to-radiation efficiencies near 9%. Optimum $CO_2:N_2:$He gas composition was found to be 1.5 : 1.5 : 7, operated at atmospheric pressure. Current pulse durations for the 60 kV discharges approximated 1 $\mu$s, with maximum amplitudes of 18 A per pin. Onset of lasing occurred near the end of the discharge with pulse half-widths of 60 to 150 ns. Increasing the electrode separation to 6 cm, doubling the capacitance of the system, and changing the gas composition to a 0.4-atmosphere 1 : 1 : 2 mixture doubled the output energy. Concentric electrode configurations using a wire cathode along the laser axis, surrounded by a cylindrical anode, lased at reduced powers, maximizing at 1.4 MW. (auth)

**23660** (LRP-55/72) DIFFERENTIAL SYSTEM FOR MAGNETIC PROBE MEASUREMENTS. Ignat, D. W.; Heym, A. (Centre de Recherches en Physique des Plasmas, Lausanne (Switzerland)). Aug. 1972. 24p. Dep. NTIS (U. S. Sales Only).

Use of an integrated circuit differential amplifier and passive RC integration provides magnetic probe signals of large bandwidth untroubled by electric pickup. (auth)

**23661** (TID-26274) HCN LASER SCATTERING SYSTEM FOR PLASMA DIAGNOSTICS. Sandel, F. (Cornell Univ., Ithaca, N. Y. Lab. of Plasma Studies). Jan 1972. Contract AT(11-1)-3165. 76p. Dep. NTIS.

The feasibility of far-infrared diagnostics as applied to a device such as the Cornell THM-II turbulent heating device is investigated. The design of the laser experiment is described in some detail. The operation and characteristics of the cyanide laser are discussed. The detection problem and the lightguide system are also described. (MOW)

**23662** HIGH-PERFORMANCE LASER-EXCITED INTERFEROMETER FOR MEASURING ELECTRON DENSITIES. Funk, L. W. Vancouver, B. C.; Univ. of British Columbia (1972). National Library of Canada, Ottawa.

Thesis (Ph.D.)

Significant improvements in several aspects of laser-excited interferometer design are included in this instrument. The device utilizes plasma-limiting quartz tubes and a concentric resonator design to greatly simplify interferometry in the presence of transverse gradients of refractive index and improve beam overlap. The techniques of fractional fringe-shift interferometry in the time domain are incorporated, and provide order-of-magnitude improvements in sensitivity ($\int N_e dl \gtrsim 5 \times 10^{13}$ cm$^{-2}$) and temporal resolution ($\Delta\tau \sim \pm 25$ nsec). Electronic circuitry provides a direct, continuous readout of electron density. Measurements were made on a z-pinch discharge that are impossible in any other way, confirming the usefulness of the discharge as a spectroscopic source and revealing details of the pinch mechanism. (Diss. Abstr. Int., B)

**23663** MEASUREMENTS OF ENERGY DISTRIBUTION OF PLASMA IONS WITH AN ELECTROSTATIC ANALYZER. Sodowski, M.; Skladnik-Sadowska, E.; Sudlitz, K. (Inst. of Nuclear Research, Swierk, Poland). Nukleonika; 17: No. 10, 495-507(1972).

Measurements of ion energies and impurity concentrations provide direct knowledge of plasma composition and its thermodynamic state. In this paper an electrostatic energy analyzer with cylindrical deflector plates is described, and results of measurements performed with that instrument are presented. The detailed description of the operation and a theoretical analysis of the operational conditions of such an analyzer are given. An experimental setup for calibration measurements is described, and main results of such measurements are presented. Some results of preliminary research on energy distribution of plasma ions generated by a coaxial injector are also given. (auth)

**23664** IMPEDANCE PROBE AND DC PROBE STUDIES ON THE PLASMA OF A GLOW DISCHARGE. Sen, C.; Basu, J. (Saha Inst. of Nuclear Physics, Calcutta). J. Phys., D (London); 6: No. 2, 172-183(Jan 1973).

A plane probe acting simultaneously as an rf impedance probe and a dc probe was used for studying the collision-dominated plasma of a glow discharge. The conventional probe methods are suitably modified so as to take into account the effect of the presheath lying between the probe sheath and the undisturbed plasma. Measurements of the electron temperature and electron density were carried out under different discharge conditions. It is found that the electron temperatures, as given by the rf and dc methods, are in excellent agreement, while the corresponding electron densities differ by a factor of 2 to 3. The thickness of the positive-ion sheath formed in front of the probe was determined by the impedance method; the variation of the thickness with sheath voltage, discharge current or operating pressure is as expected. (auth)

**23665** ION SATURATION CURRENTS TO PLANAR LANGMUIR PROBES IN A COLLISION-DOMINATED FLOWING PLASMA. Clements, R. M. (Univ. of Victoria, B. C.); Smy, P. R. J. Phys., D (London); 6: No. 2, 184-195(Jan 1973).

The transition between diffusive (saturated current) and sheath-convection (current $\propto$ voltage$^{3/4}$) behavior of the current to a negative probe in a high-pressure, flowing plasma was studied theoretically. By using two physical models, where both effects are considered to be significant, one effect being dominant in one case and the other being dominant in the other case, an approximate relation is derived for the probe current in the transition between these two regimes. This transition is found to cover a variation of two orders of magnitude in ionization density if the required 10% accuracy is to be achieved. It is also found that thermoelectric and nonequilibrium effects due to cooling in the thermal boundary layer do not themselves materially affect the diffusion current. (auth)

**23666** . COMPARATIVE EXPERIMENTAL STUDY OF ELECTRON AND POSITIVE-ION CURRENT COLLECTION BY A CYLINDRICAL LANGMUIR PROBE UNDER ORBITAL-LIMITED CONDITIONS. Smith, D.; Plumb, I. C. (Univ. of Birmingham, Eng.). J. Phys., D (London); 6: No. 2, 196-205(Jan 1973).

It is shown that within a predictable restricted range of charge density, linear plots of $i_e^2$ and $i_+^2$ against the probe–plasma potential difference could be obtained for positively and negatively biased probes respectively; which is in qualitative agreement with the Langmuir theory of orbital-limited-current collection. However, the values of the electron density ($n_e$) and the apparent positive-ion density ($n_+$) deduced from the slopes of the above plots were not equal; $n_+$ always exceeding $n_e$ and related empirically to it via the mass of the positive ion $m_+$ (in amu) thus: $n_+ = (1 + 0.07\, m_+^{1/2})n_e$. It is suggested from additional experimental evidence that the values for $n_e$ are accurate and the discrepancy arises as a result of the inadequate theoretical description of the positive-ion currents flowing to the negatively biased probe. The data points of Tonks and Langmuir (Phys. Rev., 34: 876-922(1929)) and of Shaeffer (1971) obtained in arc plasmas are shown to be consistent with the present results. The significance of these results to plasma diagnostics using probes is discussed. (auth)

## Kinetics (General)

**23667** (AD-749287) RESEARCH OF AEROPHYSICS INSTITUTE FOR STRATEGIC TECHNOLOGY. Semiannual Technical Summary for Period Ending 29 Feb 1972. Bloom, M. H. (Polytechnic Inst. of Brooklyn, N. Y.). 29 Feb 1972. Contract DAHC04-69-C-0077. 30p. (PIBAL-72-A; AROD-8677.28-P). NTIS.

The report contains a description of the technical problem areas and accomplishments achieved during the reporting period. In addition, a complete list of publications, presentations, lectures, etc., is included and the personnel associated with the program are listed. The research projects are in the general subject areas of fluid and plasma dynamics. (auth)

**23668** (AD-750943) ELECTRONIC NONEQUILIBRIUM IN A SUPERSONIC EXPANSION OF IONIZED GAS. McGregor, D. D. (Stanford Univ., Calif. Inst. for Plasma Research). Jul 1972. Contract F44620-68-C-0051. 284p. (SU IPR-474; AFOSR-TR-72-2049). NTIS.

An experimental and analytical study of nonequilibrium among the populations of the excited levels of electric-arc-heated potassium vapor injected in argon/helium gas flows passing through a Mach 2.2 supersonic nozzle is presented. Spectroscopic measurements (line intensity and line reversal) of the gas were performed upstream of the nozzle and at the nozzle exit. As the plasma proceeded through the nozzle the gas temperature dropped from 2500 to 1000 K in 0.00003 s. The electron temperature also decreased rapidly, causing the free electrons to recombine with ions of potassium. The recombined electrons passing through the energy level structure of potassium formed the basis of the electronic nonequilibrium. A theory was written describing quantitatively the behavior of the excited-atom populations. The electronics populations of expanded potassium vapor were observed to depart from equilibrium in qualitative accordance with the theoretical predictions. (auth)

**23669** (JAERI-M-4726) FUNDAMENTAL QUANTITIES AND BASIC DATA OF PLASMA PHYSICS FOR THE EXPERIMENTS IN JFT-2. Suzuki, N.; Funahashi, A.; Itoh, S. (Japan Atomic Energy Research Inst., Tokyo). Feb 1972. 98p. NTIS (U. S. Sales Only).

Fundamental quantities and basic data are given, which are useful in the experiments in JFT-2, a tokamak-type apparatus. Quantities and data in the form of graphs are the following: (a) fundamental quantities in plasma physics such as plasma frequency, Larmor radius, thermal velocity and relaxation time in classical collision processes, (b) physical quantities characteristic of the tokamak-type apparatus, including bounce frequency of trapped particles and neoclassical transport coefficient, and (c) atomic and molecular collision cross sections possible in the JFT-2 plasma. (auth)

**23670** (NP-19681) WILLS PLASMA PHYSICS DEPARTMENT TWENTY-FOURTH SIX-MONTHLY PROGRESS REPORT, 1st JULY-31st DECEMBER 1972. (Sydney Univ. (Australia). School of Physics). 1972. 11p. (PR-24). Dep. NTIS (U. S. Sales Only) $3.00.

Brief descriptions of research during this period are given for the following topics: (1) plasma sources, (2) hydromagnetic shock waves, (3) rotating plasmas, (4) ion cyclotron work, (5) cyclotron harmonic waves, (6) far-infrared, and (7) laser diagnostics. (MOW)

**23671** BREAKDOWN POTENTIAL AND FIRST IONIZATION COEFFICIENT IN A TOWNSEND DISCHARGE IN CESIUM VAPOR. Garamoon, A. A. W. M.; Surplice, N. A. (Univ. of Keele, Eng.). J. Phys., D (London); 6: No. 2, 206-211(Jan 1973).

The breakdown potential in a Townsend discharge in cesium vapor was measured over the range $p_0 d = 0.1$ to 1 torr cm. Minimum breakdown potentials of 308 and 332 V were found at $p_0 d = 0.22$ torr cm in two discharge tubes with different ratios of electrode diameter to separation (8.8 and 3.0 respectively). The ionization coefficient $\eta (= \alpha/E)$ was deduced from the I/V characteristics under the same conditions as the breakdown potential; and some estimates were made of the generalized secondary ionization coefficient $\omega/\alpha$. The results for the breakdown potential are considered to be more reliable than those for the two ionization coefficients. (auth)

**23672** PERTURBATION OF A MAGNETIZED PLASMA BY A RAPIDLY MOVING CHARGE. Dubovoi, A. P.; Moskalenko, A. M. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). Zh. Eksp. Teor. Fiz.; 64: No. 1, 146-152 (Jan 1973). (In Russian).

The flow of a plasma located in a strong external magnetic field $B_0$ around a weak charge is considered. The velocity of the charge $V_0$ is much greater than the ion thermal velocity but much smaller than the electron thermal velocity and is inclined to the field. Distributions of the electric potential and perturbations of the electron and ion concentrations $\delta N$ along the z axis perpendicular to the $(V_0, B_0)$ plane and passing through the charge and also distributions for large and small distances from the charge $\rho$ in the $(V_0, B_0)$ plane are obtained with quadratic accuracy with respect to a small dimensionless charge. The angular distribution near the symmetry plane $z = 0$ has a petal-like structure characteristic of supersonic streamlining. In contrast to the case of an unmagnetized plasma now $\delta N_e \neq \delta N_i$. At distances greatly exceeding the ion Larmor radius $L_i$ ($|z| \gg L_i$, $\rho \gg L_i V_0/v_{Ti}$) the results hold for arbitrary magnetic field strengths. (auth)

## Kinetics (Experimental)

**23673** (AD-748465) TIME RESOLVED X-RAY SPECTRAL MEASUREMENT SYSTEM. Technical Report, 1 October 1970–1 December 1971. Johnson, D. J. (Air Force Weapons Lab., Kirtland AFB, N. Mex.). May 1972. 52p. (AFWL-TR-72-40). NTIS.

Computer codes were developed to determine x-ray filter/solid-state detector response curves and to reduce filter–detector oscilloscope trace data obtained from pulsed plasma devices. The first of these codes also generates theoretical x-ray spectra and calculates anticipated detector outputs to aid in unfolding spectra. Eleven Ross filter pairs are also presented which, when used with silicon PIN detectors, give time-resolved x-ray spectral information in the energy range from 5 to 67 keV. (auth)

**23674** (COO-3436-1) EXPERIMENTAL STUDY OF PLASMA TURBULENCE. Final Technical Summary of Research. Levi, E. (Polytechnic Inst. of Brooklyn, N. Y.). 31 Oct 1972. Contract AT(11-1)-3436. 14p. Dep. NTIS.

The various technical aspects of the individual research projects are discussed. The following areas were researched: (1) a hollow cathode discharge system, (2) electron cyclotron resonance plasma source, and (3) studies on diagnostic techniques. (MOW)

**23675** (FRNC-TH-319) EXPERIMENTAL DETERMINATION OF THE ION DISTRIBUTION FUNCTION OF A PLASMA CONFINED IN THE DECA II B MAGNETIC WELL. Chatelier, M. (Paris Univ. (France)). 1972. 52p. (In French). Dep. NTIS (U. S. Sales Only).

Thesis.

A plasma confined in a DECA II B magnetic mirror machine was studied experimentally by analyzing in phase space and time the neutral atom flux emitted by the plasma. This method is particularly useful for determining the ion distribution function and relating this function to the macroscopic parameters. Two periods of evolution were observed in the plasma: a first period extending from 0 to 1 ms dominated by an angular redistribution of the ion velocities as a function of their energies; a second period occurring immediately after the first and dominated by resonant charge exchange. The first process is accompanied by a populating of the high-energy part of the ion distribution function in the median plane. This result disagrees with the hypothesis that the distribution function can be expressed in the form of a product between two $\theta$ and $\phi$ independent functions. The measurement device is not sufficiently compact to enable a systematic exploration of the plasma to be made, which is a considerable handicap to the utility of the method. (France)

**23676** (LRP-56/72) OBSERVATION OF SLOWLY VARYING MAGNETIC INDUCTION IN A ROTATING MAGNETIC FIELD PINCH. Ignat, D. W.; Heym, A.; Hofmann, F.; Lietti, A. (Centre de Recherches en Physique des Plasmas, Lausanne (Switzerland)). Nov 1972. 24p. Dep. NTIS (U.S. Sales Only).

Recent measurements on a rotating magnetic field pinch reveal, in the plasma core, large magnetic fields that change slowly in time. Computations based on MHD theory show qualitatively that such fields should be expected, but they fail to reproduce the observed spatial extent and magnitude. Trapping and compression of the induction generated by the first half cycle of the rotating field is apparently a primary cause of the phenomenon. (auth)

**23677** DENSE PLASMA FOCUS. Infeld, E.; Skorupski, A. (Instytut Badan Jadrowych, Warsaw). Nukleonika; 17: No. 11, 565-582(1972).

The main experimental devices and most important results obtained in dense plasma focus experiments are described. A critical discussion of related theoretical models is also given. (auth)

**23678** VELOCITY DISTRIBUTION OF THE ELECTRONS IN AN ELECTRON CYCLOTRON RESONANCE PLASMA. Greene, D. G. S.; Shohet, J. L. (Univ. of Wisconsin, Madison). Plasma Phys.; 15: No. 1, 5-19(Jan 1973).

The velocity distribution of the electrons in an electron cyclotron resonance plasma has been measured by three methods: bremsstrahlung intensity, bremsstrahlung polarization, and Langmuir probe characteristics. Various anisotropic velocity distributions were used in theoretical calculations for all three methods in an attempt to determine the actual distribution. For this experiment a two temperature loss-cone distribution gives the best fit to the data. (auth)

**23679** OPTICAL ORIENTATION OF METASTABLE $^3$He ATOMS AND ITS EFFECT ON THE ELECTRON DENSITY AND IRRADIATION OF HELIUM ATOMS IN A PLASMA. Zhitnikov, R. A.; Blinov, E. V.; Vlasenko, L. S. (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Eksp. Teor. Fiz.; 64: No. 1, 98-107(Jan 1973). (In Russian).

The orientation of metastable $^3$He atoms is found to affect the emission of helium atoms and the electron density in a helium plasma during optical pumping of $^3$He atoms in the $2^3S_1$ state by light from lamps containing $^3$He and $^4$He. These phenomena have also previously been observed on optical orientation of metastable $^4$He atoms. Various hypotheses explaining the phenomena are verified under various experimental conditions. (auth)

## Kinetics (Theoretical)

**23680** (CEA-N-1573) NUMERICAL MODELS SIMULATING PLASMAS IN THE TOKAMAK MACHINE. Nguyen Thuy [illegible] (Commissariat a l'Energie Atomique, Saclay (France). Cen[illegible] d'Etudes Nucleaires). Nov 1972. 35p. (In French). Dep. NTIS (U. S. Sales Only).

The partial-derivative equations of the tokamak problem are solved using three different methods: direct method, noncoupled Newton Method and coupled Newton method; the different results are compared. (France)

**23681** (COO-3086-17) RESEARCH IN COMPUTATIONAL PLASMA PHYSICS. Progress report, June 1, 1972–May 31, 1973. Chu, C. K. (Columbia Univ., New York). 15 Feb 1973. Contract AT(11-1)-3086. 7p. Dep. NTIS.

Research in computational plasma physics is proceeding well at Columbia. Problems being worked on or having been completed during the past year include: (1) Two-dimensional single-fluid code for the shock tube. (2) Simulation of stuffing field. (3) Further applications of the two-fluid one-dimensional code of Schneider. (4) Heat transfer studies for the shock tube. (auth)

**23682** (INR-P-1377/7/PP) ON THE SCATTERING OF LASER LIGHT FROM A MARGINALLY STABLE HYDROGEN PLASMA. Infeld, E.; Skorupski, A.; Zakowicz, W. (Institute of Nuclear Research, Warsaw (Poland)). 1972. 13p. INIS.

In recent experiments light has been scattered from hydrogen plasmas in which the electron component was drifting relative to the ion component. A lack of precise knowledge of the drift velocity corresponding to marginal stability, as well as of what is to be expected when marginal stability is reached, has led to a certain amount of vagueness in interpreting these experiments. The present work gives an exact division of parameter space into stable and unstable regions. The dividing line in the space of $T_+/T_-$ versus $v_d/v_{the}$ is seen to have two segments, for which the wave number k that becomes unstable first is non-zero (previously there was thought to be only one). The values of the critical wave numbers are given. An error often made in calculating the scattered spectrum $S(k,\omega)$ near marginal stability is pointed out. Lastly, some comments on a recent laser scattering experiment (KRONAST and PIETRZYK 1971) are offered. (auth)

**23683** (IPP-6/113) INVERSE PROBLEM OF TURBULENCE. Graeff, P. (Max-Planck-Institut fuer Plasmaphysik, Garching (West Germany)). Aug 1972. 93p. (In German). Dep. NTIS (U. S. Sales Only) $6.75.

In the theory of strong turbulence from Reynolds to the present day, there exist no reliable approximation schemes. There are, however, several exactly soluble cases. For example, Cook and Taylor have recently shown this for the case of a two-dimensional guiding-center plasma. One can therefore ask: what properties must an equation of motion have so that it leads to a soluble turbulence problem. For Gaussian measure, the situation is clear and the different possibilities can be conveniently classified. (auth)

**23684** (IPPJ-131) EQUATIONS FOR A PLASMA CONSISTING OF MATTER AND ANTIMATTER. Nelson, A. H.; Ikuta, K. (Nagoya Univ. (Japan). Inst. of Plasma Physics). Aug 1972. 42p. NTIS (U. S. Sales Only).

A set of fluid-type equations is derived to describe the macroscopic behavior of a plasma consisting of a mixture of matter and antimatter. The equations are written in a form that displays the full symmetry of the medium with respect to particle charge and mass, a symmetry absent in normal plasmas. This symmetry of the equations facilitates their manipulation and solution, and by way of illustration the equations are used to analyze the propagation of electromagnetic and acoustic waves through a matter–antimatter plasma. Some differences from the propagation of such waves in a normal plasma are noted. (auth)

**23685** (IPPJ-135) INDUCTION OF DC CURRENT BY AN RF TRAVELLING WAVE IN A STRONG MAGNETIC FIELD. Midzuno, Y. (Nagoya Univ. (Japan). Inst. of Plasma Physics). Aug 1972. 18p. (In Japanese). NTIS (U. S. Sales Only).

On the basis of a simple model, the dc current induced by an rf traveling wave is calculated. It is assumed that the initial velocity distribution of electrons is Maxwellian and that the electrons move adiabatically on a magnetic line of force. An expression is developed for the average electron velocity attained when $B_W/B_0 \ll 1$. An evaluation and discussion are made on the required rf power for sustaining the plasma current in Golovin's model of the Tokamak fusion reactor. (auth)

**23686** (ITF-72-148-E) TRANSITION PROBABILITY APPROACH TO THE THEORY OF PLASMAS. Ichimaru, S.; Yakimenko, I. P. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1972. 40p. Dep. NTIS (U. S. Sales Only).

Theories of fluctuations and correlations in plasmas are reviewed with emphasis on the concept of the transition probability of a test particle. The simple cases of electrostatic correlations in uniform unbounded plasmas are considered first. It is shown that the transition-probability approach reproduces an exact result obtained from a solution of the kinetic equations for stable, quiescent plasmas. The transition-probability approach is then extended to the cases of inhomogeneous unbounded plasmas. Finally, general cases of electromagnetic correlations in homogeneous bounded plasmas are considered. Various applicational examples are discussed; usefulness of the transition-probability approach is thereby emphasized. (auth)

**23687** (ITF-72-154-P) RELATION BETWEEN NONLINEAR SUSCEPTIBILITY AND FLUCTUATIONS IN PLASMA. Sitenko, A. G. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1972. 11p. (In Russian). Dep. NTIS (U. S. Sales Only).

The nonlinear electrodynamic properties of plasma are considered. It is shown that nonlinear plasma susceptibility is expressed by higher-order correlation functions for the charge-density fluctuations, neglecting interparticle interaction. A generalized fluctuation dissipative relation for nonlinear electrodynamic media is obtained. (auth)

**23688** (TRITA-EPP-73-1) BETA LIMITATION OF ROTATING PLASMAS. Lehnert, B. (Kungliga Tekniska Hogskolan, Stockholm (Sweden)). 30 Jan 1973. 19p. Dep. NTIS (U. S. Sales Only).

In earlier experiments with the rotating plasma device F III, having a large radial ratio, the voltage was observed to be limited to values being much lower than those predicted by the critical-velocity phenomenon at the end insulators. A possible explanation of this behavior is provided by the "centrifugal expansion instability", which sets in at a critical beta value before the velocity limit has been reached. These results not only agree with theory on this particular mode of instability, but also provide additional support to earlier conclusions about the stability of impermeable plasmas bounded by limiters. (SW)

**23689** CYCLOTRON RESONANCE IN AN INHOMOGENEOUS PLASMA. Laird, M. J. (King's Coll., London). J. Plasma Phys.; 8: No. 2, 255-260(Oct 1972).

The motion of a charged particle in a transverse wave of varying amplitude, wavelength, and phase speed propagating along a uniform magnetic field, together with a longitudinal electric field, is investigated. The equations of motion, in Hamiltonian form, are reduced to a system with two degrees of freedom in which integrable cases appear naturally. It is shown that particles may be locked in resonance with the wave, and expressions are found for the energy and momentum of such particles in terms of the phase speed. (auth)

**23690** EVOLUTION EQUATIONS OF THE COHERENCE FUNCTION IN AN INHOMOGENEOUS, RELATIVISTIC PLASMA. I. General Theory. Sergysels, R. (Univ. Libre, Brussels); Balescu, R. Transp. Theory Statist. Phys.; 2: No. 4, 295-309 (1972).

Two general evolution equations are derived for the space–time autocorrelation function of the electric field in an inhomogeneous, relativistic plasma. The powerful methods of nonequilibrium statistical mechanics are used to show that these equations can be considered to be generalizations of the radiative-transfer equation. (auth)

**23691** EVOLUTION EQUATIONS OF THE COHERENCE FUNCTION IN AN INHOMOGENEOUS, RELATIVISTIC PLASMA. II. Interpretation of the General Equations; Approximations. Sergysels, R. (Univ. Libre, Brussels); Balescu, R. Transp. Theory Statist. Phys.; 2: No. 4, 311-319(1972).

The two general evolution equations derived in the first paper of this series are interpreted. Some approximations to reduce the general equations to usable forms are presented. (auth)

**23692** BROWNIAN MOTION OF ELECTRONS IN TIME-DEPENDENT MAGNETIC FIELDS. Iverson, G. J.; Williams, R. M. (Univ. of Miami, Coral Gables, FL). J. Phys., A (London); 6: No. 1, 106-119(Jan 1973).

The behavior of a weakly ionized plasma in slowly varying time-dependent magnetic fields is studied through an extension of Williamson's stochastic theory (J. Phys. A., 1: 629-44(1968)). In particular, attention is focused on the properties of electron diffusion in the plane perpendicular to the direction of the magnetic field, when the field strength is large. It is shown that, in the strong-field limit, the classical $1/B^2$ dependence of the perpendicular diffusion coefficient is obtained for two models in which the field B(t) is monotonic in t and for two models in which B(t) possesses at least one turning point. (auth)

**23693** LYMAN-$\alpha$ PROFILES AND THE LTE ASSUMPTION. Voslamber, D. (CEN, Fontanay-aux-Roses, France). Phys. Lett., A; 42A: No. 7, 469-470(29 Jan 1973).

Small deviations from LTE in wall-stabilized arcs might partially explain the discrepancy between theoretical and experimental Ly-$\alpha$ profiles. (auth)

**23694** STATISTICAL MECHANICS OF PLASMAS. Kim, S. H. Fort Collins, CO; Colorado State Univ. (1972). 95p. University Microfilms Order No. 73-2798.

Thesis (Ph.D.).

The thesis consists of four interrelated parts concerned with the development of new theoretical foundations for the (1) mathematical description of collisionless plasmas, (2) the statistical dynamics of random plasma continua, (3) the application of these foundations to the evaluation of the spectral energy density of the turbulent electric field in wavenumber space, and (4) the calculation of the broadening of hydrogen-like spectral lines by turbulent electric fields. The last investigation permits determination of the properties of turbulent plasmas from the observed stark broadening of spectral lines. (MOW)

**23695** NONLINEAR RADIO-FREQUENCY RESPONSE OF A NON-UNIFORM PLASMA SLAB-CONDENSER SYSTEM WITH REALISTIC DENSITY AND VELOCITY PROFILES. Ballieu, R.; Messiaen, A. M.; Vandenplas, P. E. (Laboratorium voor Plasmafysika, Brussels). J. Plasma Phys.; 8: No. 2, 113-126(Oct 1972).

The nonlinear behavior of a realistic one-dimensional bounded plasma (specifically, the classical plasma slab-condenser system) is computed by an iterative perturbation method. The results indicate, somewhat unexpectedly, that the influence of the rf field on the static density profile and on the resonance spectrum is much smaller than would have been inferred from a previous analysis of an unbounded plasma. (auth)

**23696** TURBULENCE IN WEAKLY IONIZED PLASMA. Bugnolo, D. S. J. Plasma Phys.; 8: No. 2, 143-158(Oct 1972).

The results of two experiments in a weakly ionized turbulent argon plasma are compared with a theory for the spacewise spectrum of the electron–ion density fluctuations of the plasma. The theoretical predictions are in reasonable agreement with the results of these experiments. The theory, based on a quasi-static formulation of the Boltzmann equations, is a direct consequence of the Boltzmann equations for the electrons, ions and neutrals in the weakly ionized plasma. A Heisenberg model is used for the turbulent diffusion coefficient of the plasma. (auth)

**23697** MOMENT EQUATIONS AND OHM'S LAW. Greene, J. M. (Flinders Univ. of South Australia, Bedford Park). Plasma Phys.; 15: No. 1, 29-36(Jan 1973).

The moment equations of plasma physics are examined and are arranged in a form that is directly Galilean-invariant, suited for taking advantage of the small charge and current densities that occur in a dense plasma. Results are given in a form that is symmetric in the various species. (auth)

**23698** COMPUTER SIMULATION OF ANISOTROPIC MAGNETOPLASMA SYSTEMS IN CYLINDRICAL AND TOROIDAL GEOMETRY. Sharp, W.; Taylor, J. C. (Univ. of Glasgow). Comput. Phys. Commun.; 4: No. 1, 95-99(Oct 1972).

The computer simulation of toroidal magnetoplasma systems is based on a one-fluid model consisting of evolution equations for plasma density, velocity, and temperature and for the magnetic induction. Anisotropic resistivity is used in the calculation as it stands but viscosity and thermal conductivity are neglected. These can be added without essentially changing the algorithm of the calculation, which is of partially implicit type. It also uses a method of decoupling the unknown components of the state vector, thus reducing the weight of matrix inversion necessary. Calculations are found to be stable for many regimes of operation of the system, but the Tokamak regime is too severe. (auth)

**23699** COMPUTER INVESTIGATION ON NONLINEAR DYNAMICAL PROBLEMS OF PLASMA THEORY. Makhankov, V. G.; Shchinov, B. G. (Joint Inst. for Nuclear Research, Dubna, USSR). Comput. Phys. Commun.; 4: No. 3, 327-332(Dec 1972).

Computer studies of certain dynamical problems of plasma theory and that of collective acceleration of ions which reduce to the solution of nonlinear integro-differential equations are presented. (auth)

**23700** NUMERICAL SIMULATION OF THE EVOLUTION OF A PLASMA IN A CONFINEMENT DEVICE. Boujot, J. P. (CEN, Saclay, France); Mercier-Soubbaramayer, C. Comput. Phys. Commun.; 4: No. 1, 89-94(Oct 1972).

A numerical simulation of the evolution of a plasma in a Tokamak device is given. A conversational program is realized in a modular form. Three types of application of the code are described: interpretation of experimental results, extrapolation computations for future devices, and analysis of some prospective problems of fusion reactors. (auth)

**23701** RATE OF ENERGY TRANSFER IN A PLASMA. Alyamovskii, V. N. (Lebedev Inst. of Physics, Moscow). Zh. Eksp. Teor. Fiz.; 64: No. 1, 164-167(Jan 1973). (In Russian).

An expression that does not contain any cutoff parameters is obtained for the rate of variation of the mean energy of nonrelativistic homogeneous plasma components due to Coulomb collisions. If the light component is the hotter, the effective electron–ion interaction range significantly exceeds the Debye ion length due to exchange of ion-sound waves. (auth)

## Production

**23702** (UCRL–74341) HIGH-INTENSITY LASER-LIGHT INTERACTION WITH THE SURFACE OF SOLID DEUTERIUM. Shearer, J. W. (California Univ., Livermore. Lawrence Livermore Lab.). 29 Nov 1972. 35p. (CONF-721213–1). Dep. NTIS.

From Winter meeting in the west of the American Physical Society; Los Angeles, California, USA (29 Dec 1972).

Current research on these laser-beam interactions for laser pellet fusion research application is discussed. The basic theory for transverse electromagnetic waves in plasma is reviewed. Density gradients at the solid surface are described along with collisional absorption coefficients. Anomalous plasma effects are then outlined. (MOW)

**23703** LASER-INITIATED FUSION: KEY EXPERIMENTS LOOMING. Boyer, K. (Los Alamos Scientific Lab., NM). Astronaut. Aeronaut.; 11: No. 1, 28-38(Jan 1973).

The possibilities of laser fusion are reviewed. The review discusses such concepts as collisional absorption, resonant absorption, collisionless absorption, and energy transport. The developments in laser technology are outlined. Some possible application techniques are also described. (MOW)

## Stability

*Refer also to abstract 23658.*

**23704** (IPP-6/112) COLLISIONLESS DISSIPATION OF A CROSS FIELD ELECTRIC CURRENT. Biskamp, D.; Chodura, R. (Max-Planck-Institut Fuer Plasmaphysik, Garching (West Germany)). Aug 1972. 39p. (IPP-1/129). Dep. NTIS (U. S. Sales Only) $4.00.

A detailed analysis is given of the development of the electrostatic turbulence excited by a cross-field current in a high-density ($\omega_{pe} \gg \Omega_e$) collisionless plasma, as obtained from 1- and 2-D computer simulations. The critical velocity for instability is found to be about half the value for the two-stream instability, in contrast to the electron cyclotron drift instability. In 1 D, the system remains self-similar in the turbulent phase, $\langle\tilde{E}^2\rangle/8\pi nT \simeq$ const, while the electron thermal velocity and the effective collision frequency increase linearly with time, $\nu_{eff} \propto \Omega_e t$, in agreement with the theory of coherent trapped-electron heating by Forslund et al. The switch-off drift velocity, however, is $v_{ds} \simeq 2c_s$, and hence the thickness of a magnetic sheath would be $\Delta \sim c/\omega_{pi}$ instead of $\Delta \sim c/\Omega_e$. In 2 D the two projections are investigated, the j–B plane (j = current) and the plane perpendicular to B, the latter being the more relevant. The heating is much less efficient than in 1 D, $\nu_{eff/max} \simeq 5 \times 10^{-3}\ \omega_{pe}$. It is found that $\nu_{eff} \propto \langle\tilde{E}^2\rangle/8\pi nT$, indicating stochastic dissipation. The gross features of the 2 D behavior correspond to the picture of ion-sound instability with electron runaway prevented by gyration. (auth)

**23705** (IPP-6/114) RESISTIVE INSTABILITIES IN PLASMAS WITH A SHEAR FLOW. Hofmann, I. (Max-Planck Institut fuer Plasmaphysik, Garching (West Germany)). Aug 1972. 89p. (In German). Dep. NTIS (U. S. Sales Only) $6.50.

Resistive instabilities, with particular emphasis on the tearing instability, are considered in a plane sheet pinch with shear bulk plasma flow. Analytical problems in the vicinity of singular points in the complex plane due to the small-resistivity expansion are studied in detail, and the uniform convergence of a suitably defined solution is shown. The scaling law for the growth rate is found to be $\mathrm{Re}\,\omega \sim \tau_R^{-1/3}\ \tau_{\mathrm{Kelv.-Helmh.}}^{-2/3}$ ($\tau_R$ resistive diffusion rate, $\tau_{\mathrm{Kelv-Helmh.}} \sim V_0'(Z_0)$ a typical growth rate of a Kelvin–Helmholtz instability), where $v_0'(Z_0)$ means a velocity gradient in the resistive singular layer at $Z_0$ ($kB_0(Z_0) = 0$); if $v_0'(Z_0)$ vanishes, one obtains the well-known scaling law when no flow is present: $\omega \sim \tau_R^{-3/5}\ \tau_H^{-2/5}$ ($\tau_H$ ideal hydromagnetic time). The region of unstable modes depends on the quotient (fluid kinetic energy/magnetic field energy); stabilization can be obtained theoretically if this quotient decreases strongly enough away from the resistive singular layer. (auth)

**23706** (ITF-72-159-E) EXPLOSIVE INSTABILITIES OF WAVES IN PLASMAS WITH SPECIAL REGARD TO DISSIPATION AND PHASE EFFECTS. Wilhelmsson, H. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1972. 16p. Dep. NTIS (U. S. Sales Only).

The problem of explosive instability in plasma is studied with particular emphasis on the influence of dissipation and frequency indeterminacy on the dynamic phase locking in a system of three waves. (auth)

**23707** (LGI/R-72/9-E) EQUILIBRIUM CHARACTERISTICS AND KRUSKAL–SHAFRANOV LIMIT OF A HOLLOW CYLINDRICAL PLASMA PINCH IN A TOROIDAL MAGNETIC FIELD. Geiger, M. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratorio Gas Ionizzati). Nov 1972. 39p. Dep. NTIS (U. S. Sales Only) $4.00.

The radial equilibrium of a cylindrical plasma sheet of finite thickness within a concentric metallic casing is investigated under the assumptions that: (1) the magnetic confining field is a vacuum field with axial and toroidal components, $B_z$ and $B_\varphi$ respectively, (2) the plasma has a sharp boundary and carries surface currents only, (3) there is inside the plasma a trapped toroidal field $B_{\varphi,I}$ and (4) the plasma pressure is constant or, in a second case, varies with the radius such that the total energy remains constant. Equilibrium characteristics are calculated for this model and plotted in equilibrium charts which indicate the displacement of the plasma as a function of its thickness (in normalized quantities), using curves of constant $\beta$ and tg$\gamma$. Chart parameters are the aspect ratio a and the factor k. Charts for different values of a and k illustrate the influence of the toroidicity and the relative height of the core on the equilibrium displacement. These relations are discussed in detail and show the important openings for possible confinement devices operating at higher $\beta$ and higher toroidal current. (auth)

**23708** (ORNL-TM–4076) SOME TECHNIQUES FOR DETERMINING TENSOR PRESSURE EQUILIBRIA. Hedrick, C. L.; Guest, G. E.; Nelson, D. B. (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 30p. Dep. NTIS $3.50.

Several iterative techniques for computing finite-beta, tensor-pressure equilibrium of guiding-center plasmas are described. Equilibrium equations that apply for various configurations are cast into a form suitable for the iteration schemes. Several relations needed for studies of equilibrium and stability are given. More general models are then described. (MOW)

**23709** (ORNL-TM-4109) STABILITY OF ANISOTROPIC EQUILIBRIA IN CLOSED LINE TORI. Nelson, D. B.; Hedrick, C. L.; Spies, G. O. (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 34p. Dep. NTIS $3.75.

The stability of anisotropic closed line tori with pressure surfaces was examined, and simple conditions were found for stability to various perturbations. Because the positive kinetic term $W_K$ was ignored, each of these is only sufficient for stability to the given perturbation. $W_K$ can also be included in all but the final condition at no cost in analytic difficulty (but some in complexity). (auth)

**23710** (TID-26285) PLASMA INSTABILITIES AND WAVES EXCITED BY AN ANISOTROPIC ENERGY DISTRIBUTION PRODUCED BY ELECTRON CYCLOTRON RESONANCE. Final Report. (Wisconsin Univ., Madison). 15 Jun 1972. Contract AT(11-1)-1695. 161p. Dep. NTIS.

Electron cyclotron resonance heating of a plasma is known to produce anisotropic electron distributions. This research has studied the dynamics of the heating process when the plasma is subjected to a microwave pulse at, above, or below the ecr frequency and the waves and/or instabilities produced by the anisotropic distribution in a magnetic mirror machine. The plasma is produced either by high-power (200 kW), short (2 μsec), repetitive (360 Hz), 3-cm microwave pulses at high pressure (–$10^{-3}$ torr), or by a lower-power (20 kW), long (1 msec) microwave pulse at low pressure (–$10^{-5}$ torr). The plasma was examined with the following diagnostics: (1) probes, (2) diamagnetic signals, (3) $\vec{E} \times \vec{B}$ energy analyzer, (4) microwave-cavity perturbation, (5) x-ray bremsstrahlung detectors, (6) microwave emission, and (7) optical monochromator. The perpendicular and parallel energies were measured as a function of time for various experimental parameters such as pulse length, pulse spacing, microwave power, gas pressure, magnetic field strength and mirror ratio. The resulting heating rates, and rates of energy transfer to the ions were compared with theoretical calculations. The decay of energy and density in the plasma were measured after the heating pulse to determine the relative importance of various loss mechanisms. Theoretical work included the calculations of intensity and polarization of free–free bremsstrahlung from a relativistic plasma to determine the importance of higher-order terms in the Born approximation, and an estimate of the synchrotron radiation from the plasma. A theoretical model for resonance and off-resonance heating was compared to the experiment. Computer-simulation experiments were performed to test the theoretical predictions and to make comparisons with experimental results. (auth)

**23711** NONLINEAR STABILIZATION OF COLD BEAM–PLASMA INSTABILITY. Gupta, M. R. (Centre of Advanced Study in Applied Mathematics, Calcutta). J. Plasma Phys.; 8: No. 2, 159-168(Oct 1972).

Nonlinear stabilization of cold beam–plasma instability is studied on the basis of a theory of strong plasma turbulence. Calculations are carried out to second order in the perturbed electric field, and it is found that, for a narrow spectrum, stabilization occurs for the trapping frequency approximately equal to the linear growth rate. Nonlinear frequency correction, and also the changes in the kinetic and thermal energy densities of the beam, are calculated as the waves grow. Some points of difference between the resonant and nonresonant instabilities are discussed. (auth)

**23712** INSTABILITY OF A LARGE-AMPLITUDE PLASMA WAVE DUE TO INVERTED TRAPPED-PARTICLE POPULATION. Liu, C. S. (Inst. for Advanced Study, Princeton, N. J.). J. Plasma Phys.; 8: No. 2, 169-174(Oct 1972).

The large-amplitude plasma wave with a trapped-particle distribution monotonically increasing in energy is found to be unstable if the trapped-particle plasma frequency is greater than the bounce frequency. (auth)

**23713** COMPARISON OF WAVE PROPAGATION IN THE STATIONARY AND MOVING PLASMA: MOTION AND WAVE PROPAGATION ALONG THE MAGNETIC FIELD. Srivastava, D. N. (Bhabha Atomic Research Centre, Bombay). J. Plasma Phys.; 8: No. 2, 127-135(Oct 1972).

The three important aspects of wave propagation in a stationary and a moving plasma (namely frequency, polarization and dispersion) are compared, taking the phase refractive index of the wave as the independent variable. Wave propagation and the motion of the plasma are taken to be along the magnetic field. The plasma is assumed to consist of one species only, and the effect of collisions is neglected. Wave propagation in a moving plasma has been shown to possess several important features, such as the absence of cyclotron resonance, reversal of the sense of polarization when the phase velocity becomes equal to the plasma velocity, and the existence of backward waves for very small and very large phase velocities. (auth)

**23714** ION-SOUND INSTABILITY. Wesson, J. A.; Sykes, A.; Lewis, H. R. (Culham Lab., Abingdon, Eng.). Plasma Phys.; 15: No. 1, 49-55(Jan 1973).

A two-dimensional simulation of the nonlinear development of the ion-sound instability is described. As the instability grows, so does the resistance to the current. However, the instability leads to a modification of the electron distribution function and this, in turn, to a strong reduction in the instability growth. As a result of this development the resistance to the current falls considerably. (auth)

**23715** RECURSIVE DERIVATION OF DRIFT-KINETIC EQUATION. Hazeltine, R. D. (Univ. of Texas, Austin). Plasma Phys.; 15: No. 1, 77-80(Jan 1973).

A new derivation is presented which differs in some respects from previous drift equations, and advantages of accuracy, generality and convenience are claimed over expanded versions. (UK)

## Thermonuclear Engineering and Equipment

**23716** (BNL–17434) WARM REINFORCEMENT AND COLD REINFORCEMENT MAGNET SYSTEMS FOR TOKAMAK FUSION POWER REACTORS: A COMPARISON. Powell, J. R.; Bezler, P. (Brookhaven National Lab., Upton, N. Y.). Nov 1972. 43p. (CONF-721111-26). Dep. NTIS. $4.25.

From International meeting on the technology of controlled thermonuclear fusion experiments and the engineering aspects of fusion reactors; Austin, Texas, USA (20 Nov 1972).

Warm reinforcement and cold reinforcement magnets are compared for a range of tokamak fusion reactor sizes and fields for DT and catalyzed DD fuel cycles. In the conventional cold-reinforcement method all magnetic forces are contained by a 4 K structure reinforced with stainless steel; in the warm reinforcement method, the magnetic forces are transmitted across a low thermal conductivity structural layer to a warm (300°K) reinforcing structure made of ordinary materials. For high-field fusion reactors, the magnets are so large that the cost of the additional refrigeration load for warm reinforcement is much less than the savings in structural costs it permits. This warm reinforcement method should permit the construction of reasonable-cost ($40/kW(e)) magnets with relatively low structural stresses for catalyzed DD reactors. (auth)

**23717** (BNWL-SA-4232) CONTROLLED THERMONUCLEAR REACTOR AS A FISSION PRODUCT BURNER. Wolkenhauer, W. C. (Battelle Pacific Northwest Labs., Richland, Wash.). 1972. 75p. (CONF-720607-32). Dep. NTIS.

From 10th annual American Nuclear Society conference; Las Vegas, Nevada, USA (18 Jun 1972).

A selection of the most noxious fission products for transmutation in a fusion reactor is described. Also discussed is the activity level in curies for each fission product, and the beta and gamma emission in watts for each fission product. Maximum permissible concentrations (MPC's) for the fission-product isotopes are given. These MPC values were divided into the activities of each isotope and the isotopes were then reordered by (curies/MPC) from the highest value on down. Corresponding nuclear data for the analysis are given. (MOW)

**23718** (BNWL-SA–4403) NUCLEAR DATA REQUIREMENTS FOR FUSION–FISSION (HYBRID) REACTORS. Wolkenhauer, W. C.; Leonard, B. R. Jr. (Battelle Pacific Northwest Labs., Richland, Wash.). 1972. 18p. (CONF-730302–4; SM-170/56). Dep. NTIS.

A review is given of the historical development of the hybrid concept. Some of the principal characteristics of the system are developed. A specific hybrid design is given. A review of the analytical techniques applied to this specific design then allows for development of the nuclear data required for hybrid reactor design. (auth)

**23719** (IPP-4/105) SCALING AND SOME ELECTROTECHNICAL PARAMETERS IN TOKAMAK FUSION REACTORS.

Knobloch, A. (Max-Planck-Institut Fuer Plasmaphysik, Garching (West Germany)). Nov 1972. 26p. (CONF-720912-3). Dep. NTIS (U. S. Sales Only) $3.50.

From International school on fusion reactor technology; Erice, Italy (4 Sep 1972).

A certain scaling of the quasi-stationary Tokamak fusion reactor produced by fixing two absolute dimensions and two specific stress values is used to show the scaling of important electrotechnical parameters in the confinement and heating systems. The thermonuclear power range covered is 1 to 20 $GW_{th}$. Economical considerations are not included. (auth)

**23720** (KFTI-71-24) INVESTIGATION INTO THE MAGNETIC SYSTEM OF STELLARATOR-THERMONUCLEAR REACTOR. Georgievskii, A. V.; Ziser, V. E.; Litvinenko, Yu. A.; Skoblik, M. N.; Suprunenko, V. A.; Tolok, V. T. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko Tekhnicheskii Institut). 1971. 33p. (In Russian). INIS.

**23721** (LGI-71/2-E) PLASMA FOCUS, NEUTRON AND X-RAY DIAGNOSTICS, AND FUSION REACTOR TECHNOLOGY. Maisonnier, C. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratorio Gas Ionizzati). Apr 1971. 11p. Dep. NTIS (U. S. Sales Only) $3.00.

The characteristics of the plasma focus as a neutron and soft x-ray source are compared as follows: (a) to the fluxes of n and x that will be present in a hypothetical steady-state fusion reactor, to see whether the plasma focus can be used in tests for reactor technology; and (b) to the characteristics of a typical forthcoming experiment (the Frascati tokamak), to see whether the diagnostic methods developed for the plasma focus can present a more general interest. (auth)

**23722** (LGI-71/3-E) NEUTRON MEASUREMENTS IN A PLASMA FOCUS EXPERIMENT. Samuelli, M.; Luzzi, G.; Maisonnier, C. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratorio Gas Ionizzati). Jun 1971. 26p. Dep. NTIS (U. S. Sales Only) $3.50.

Using a 120-kJ plasma focus device of the Filippov type giving up to $2 \times 10^{11}$ neutrons per discharge in pure deuterium, careful single-shot measurements of the neutron energy spectra (by nuclear emulsions) and of the neutron fluxes (by silver activation) were carried out in three orthogonal directions. In particular, an "in situ" calibration of the detectors was performed, using a Po/Be neutron source whose energy spectrum is similar to that of D–D thermonuclear reactions. The results clearly show that there is a strong anisotropy of the ions in the coordinate system linked to the center of mass of the reacting deuterons; then thermal models such as "moving boiler" and "Morozov flow" are definitely excluded; as a simple beam–target model cannot be made consistent with the measurements, more sophisticated schemes have to be considered. (auth)

**23723** (LGI-71/9-E) EXPERIMENTAL INVESTIGATIONS ON PLASMA SNOWPLOWING. Haegi, M.; Ortolani, S. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratorio Gas Ionizzati). Nov 1971. 25p. Dep. NTIS (U.S. Sales Only) $3.25.

A coherent set of measurements has shown that, for a certain range of parameters, the axial collision of a plasma liner produced by snowplowing can be used to produce extremely high-pressure ($>10^{10}$ bars) with overall energy conversion (stored energy to compressed medium energy) of 5 to 10%. The liner, after its formation near the insulating wall, has a thickness of about 1 cm and is accelerated by the magnetic piston, which has an opacity >95%. The liner looks cylindrical and no macroinstabilities have been detected, nevertheless some jitter is present. An eventual scaling-up of this experiment would require, first, the solution of the problem of short circuit, which limits the kinetic energy that can be transferred to the liner. Further studies should also involve the liner formation, the liner internal structure, and the mechanism of the central collision. (auth)

**23724** (LGI/R-72/2-E) SELF-SIMILAR ISOTHERMAL STRONG EXPLOSION. Application to the Ignition of a Thermonuclear Medium. Somon, J. P.; Guerri, L. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratorio Gas Ionizzati). May 1972. 21p. Dep. NTIS (U. S. Sales Only) $3.25.

The self-similar isothermal solution for a strong explosion in a perfect gas is calculated in plane, cylindrical and spherical geometry. The solution is used to obtain the thermonuclear energy output in a D–T medium. Extension is made to take into account $\alpha$-particle heating and bremsstrahlung losses. The ignition condition for a spherical thermonuclear reaction wave is derived. (auth)

**23725** (SLA-73-143) CALCULATION BASES FOR CROWBAR- AND POWER-CROWBAR DISCHARGES. (Institut fuer Plasmaphysik, G.M.B.H. Garching (West Germany)). Translated for Sandia Labs., Albuquerque, N. Mex., from Report MPI-7. 30p. Dep. NTIS.

Calculations are first made for a general crowbar circuit, then crowbar discharge curves are given when load resistance is neglected. A theoretical analysis of power crowbar circuits is then given. (MOW)

**23726** (UCRL-73993(Add.)) MAGNETIC FIELD EFFECTS ON THE HEAT TRANSFER OF POTENTIAL FUSION REACTOR COOLANTS. Hoffman, M. A. (California Univ., Livermore. Lawrence Livermore Lab.). 15 Feb 1973. 5p. (CONF-720912-2). Dep. NTIS $3.00.

From International school on fusion reactor technology; Erice, Italy (4 Sep 1972).

A brief discussion of flibe heat transfer in strong transverse magnetic fields of several tesla is given. An estimation was made of the temperature drop across the first wall. Typical wall temperature data are given. (MOW)

**23727** (UCRL-74047) ENGINEERING STUDY OF THE ELECTRICAL DESIGN OF A 1000-MEGAWATT DIRECT CONVERTER FOR MIRROR REACTORS. Smith, B. H.; Burleigh, R. J.; Dexter, W. L.; Reginato, L. L. (California Univ., Livermore. Lawrence Livermore Lab.). 27 Nov 1972. 43p. (CONF-721111-27). Dep. NTIS $4.25.

From International meeting on the technology of controlled thermonuclear fusion experiments and the engineering aspects of fusion reactors; Austin, Texas, USA (20 Nov 1972).

A direct converter recovers most of the ion energy that escapes from a mirror reactor, and an injector returns the energy to the reacting plasma. The ions injected into the converter are assumed to have energies between 200 and 2000 kV, and the total beam current is 1666 A for the case studied. The different-energy ions are separated and their current is transmitted to ion sources that reinject the energy into the plasma in the form of neutral beams. Engineering problems such as sparking, high-voltage transmission, high-voltage inversion, and the electrical techniques suitable to this application are discussed. The basic design is included for a full-scale converter as it could be considered for use in a pilot reactor. (auth)

**23728** (UCRL–74326) MAGNETS FOR OPEN-ENDED FUSION REACTORS. Moir, R. W.; Taylor, C. E. (California Univ., Livermore. Lawrence Livermore Lab.). 15 Nov 1972. 60p. (CONF-721111–25). Dep. NTIS.

From International meeting on the technology of controlled thermonuclear fusion experiments and the engineering aspects of fusion reactors; Austin, Texas, USA (20 Nov 1972).

Open-ended fusion reactors will require large, high-intensity magnetic fields with unique shapes, placing stringent demands on magnet materials and design. A magnet based on the Yin–Yang coil configuration was examined in detail. The study emphasizes the technological and physics requirements that must be satisfied in a mirror reactor. Analysis of the field strength and body forces within the conductor allowed the design of a realistic but complex support structure. Aspects of neutral beams, finite length, stability, adiabaticity, density, and power distribution are discussed. One example shows a magnet of 170 kG at the mirrors costing 164 million dollars ($164M) and producing 0.9 GW of nuclear power (not net electric) at 600 keV mean energy for a D–T plasma. At 210 keV for 0.9 GW the mirror magnetic field drops to 85 kG and the cost is $45M. A simple mirror (nonminimum $|B|$) magnet with 170-kG mirror field producing 1 GW of nuclear power at 600 keV was estimated to cost $17M. (auth)

**23729** (UCRL-74357) LASERS FOR FUSION SYSTEMS. Burgess, T. J. (California Univ., Livermore. Lawrence Livermore Lab.). 6 Dec 1972. 6p. (CONF-721202-13). Dep. NTIS $3.00.

From Nuclear science symposium; Miami Beach, Florida, USA (6 Dec 1972).

The principles of initiating fusion by lasers and high-energy laser system technology are reviewed. Nonlinear optical propagation at high intensities in laser amplifiers is described and is related to the system requirements for a laser used to produce fusion. (auth)

**23730** HIGH POWER DENSITY CONTROLLED FUSION REACTOR. Christofilos, N. C. (to United States Atomic Energy Commission). U. S. Patent 3,708,391. 2 Jan 1973. Filed date 20 Sep 1971. 14p.

An Astron fusion reactor is described wherein a reaction plasma is contained in a magnetic potential well created by the interaction of the magnetic field generated by a cylindrical E layer of relativistic charged particles rotating in an axisymmetric poloidal magnetic field. Molten lithium is pumped along an elongated annular region of the poloidal field surrounding the reaction plasma exterior of the E layer to serve as a blanket for absorbing the neutron flux from the reaction plasma to generate heat and to breed tritium. The heated lithium is circulated into heat exchangers to produce steam for power generation and is treated to recover tritium for recycle or other use. Power densities several fold greater than with conventional blanket configurations may be utilized. (Official Gazette)

**23731** ENERGETIC NEUTRAL PARTICLE INJECTION SYSTEM FOR CONTROLLED FUSION REACTOR. Hamilton, G. W.; Moir, R. W.; Osher, J. E.; Post, R. F. (to United States Atomic Energy Commission). U. S. Patent 3,713,967. 30 Jan 1973. Filed date 18 Jun 1971. 10p.

The system includes an ion source, particle accelerator, and neutralizer cell for producing an energetic neutral-particle beam that is directed into the containment zone of a controlled-fusion reactor. The beam includes a significant proportion of ionized particles and a proportion of the energetic neutrals are not trapped in the containment zone. Magnetic field means are used to deflect the ionized particles from the neutral particle beam, and an ionizer cell is used to ionize neutral particles escaping from said containment zone. Means, including spaced arrays of grid structures, are arranged to deflect electrons and collect the deflected and reionized particles in a manner adapted to collect and convert the kinetic energy of the particles into electrical energy. (Official Gazette)

**23732** TOKAMAK AND THE FUTURE OF THERMONUCLEAR FUSION. Artsinovitch, L.; Chaftanov, V.; Strelkov, V. Energ. Nucl. (Paris); 14: No. 5, 374-375(Oct 1972). (F36).

It is demonstrated that tokamaks, first developed in the USSR, represent one of the most promising devices for controlled thermonuclear fusion. (France)

**23733** RADIATION DAMAGE IN FAST-BREEDER AND FUSION REACTORS. Frost, B. R. T. (Argonne National Lab., IL). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 230-236(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707–.

The production of power by fast-breeder and fusion reactors involves the generation of intense fast neutron fluxes. These neutrons cause void swelling and irradiation creep in the normal operating temperature ranges of the two reactor types and give rise to serious design problems. No facilities exist to permit the accelerated study of fast neutron effects, and strong reliance must be placed on simulation of neutron damage by heavy ions. The techniques of heavy-ion damage studies have been established, and the procedures for damage calculations taken to the stage where ion bombardment is proving a valuable tool in the development of advanced reactors. Transmutation processes are also important in these reactors but generally pose less severe problems in terms of the availability of experimental facilities; 14-MeV neutron effects in insulating materials may be an exception, because they require a high intensity neutron source. (auth)

## Wave Phenomena

**23734** (EUR-CEA-FC-672) STRUCTURE OF ELECTROMAGNETIC FIELDS AT FREQUENCIES NEAR THE HYBRID RESONANCE. Fidone, I.; Granata, G. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). Nov 1972. 29p. (In French). Dep. NTIS (U.S. Sales Only) $3.50.

The solutions to a 4th-order inhomogeneous linear differential equation occurring in investigations of the propagation of electromagnetic waves in hot inhomogeneous plasmas are studied. These studies have applications to a large range of problems such as the linear conversion of electromagnetic waves in the hybrid-resonance region, the nonlinear mixing of two electromagnetic waves, and the scattering of electromagnetic waves at the upper-hybrid-resonance frequency. (France)

**23735** (IPP-IV-45) WAVE PROPAGATION IN A WAVEGUIDE FILLED WITH AN INHOMOGENEOUS, ANISOTROPIC, CYLINDRICALLY SYMMETRIC PLASMA COLUMN. Tutter, M.; Puri, S. (Max-Planck-Institut fuer Plasmaphysik, Garching (West Germany)). Nov 1972. 35p. (In German). Dep. NTIS (U. S. Sales Only).

Differential equations are derived for the electric and magnetic field components of a radiofrequency wave propagating in an inhomogeneous, cylindrically symmetric, longitudinally magnetized plasma column contained within a metallic waveguide. The plasma profile is taken to consist of annular sheaths of uniform density and temperature and it is assumed that only two propagating modes exist in each of the sheaths. (auth)

**23736** (IPP-IV-48) MODEL FOR COHERENT SCATTERING OF ELECTROMAGNETIC WAVES FROM SPACIALLY BOUNDED PLASMA WAVES. Gehre, O.; Mayer, H. M.; Tutter, M. (Max-Planck-Institut fuer Plasmaphysik, Garching (West Germany)). Jan 1973. 30p. (In German). Dep. NTIS (U.S. Sales Only) $3.50.

The coherent scattering of electromagnetic waves from plasma waves which are bounded in the direction of their propagation is calculated. The waves are approximated by a moving multitude of homogeneous layers of alternating electron density. The scattering from sinusoidal density variations is obtained by means of a square-wave expansion. (auth)

**23737** (IPPJ-130) PHYSICAL PICTURE FOR THE ANOMALOUS PROPAGATION OF ORDINARY ELECTROMAGNETIC WAVES IN A PLASMA. Fried, B. D. (Nagoya Univ. (Japan). Inst. of Plasma Physics). Jun 1972. 10p. NTIS (U.S. Sales Only).

It is shown that the physical mechanism for the "anomalous" propagation of electromagnetic waves at frequencies below the plasma frequency, noted by several authors, is due to the deflection of particles thermal motion by the wave magnetic field, leading to a density perturbation that can be large when enhanced by some resonance. In presence of an external magnetic field, $B_0$, cyclotron resonance provides the enhancement for ordinary waves ($E \parallel B_0$). When $B_0 = 0$, a wave–particle resonance can occur, again giving rise to "anomalous" propagation, if the velocity distribution is anisotropic with respect to the wave vector k, which allows "slow" electromagnetic waves, with phase velocity less than the velocity of light. The Weibel instability, which also occurs with such a distribution function, relies upon the same physical mechanism. (auth)

**23738** (IPPJ-132) CHARACTERISTIC OSCILLATIONS OF A SHEET PLASMA. Watanabe, T.; Hatori, T. (Nagoya Univ. (Japan). Inst. of Plasma Physics). Jul 1972. 12p. NTIS (U.S. Sales Only).

An integral equation is derived for the characteristic oscillations of a sheet plasma whose width is of the order of the width of the ion Larmor radius. This equation is solved numerically, and it is shown that there exist characteristic oscillations with a frequency near the ion cyclotron frequency even for high-density plasmas. (auth)

**23739** (IPPJ-133) CHARACTERISTIC OSCILLATIONS OF A CYLINDRICAL PLASMA. Hatori, T.; Watanabe, T. (Nagoya Univ. (Japan). Inst. of Plasma Physics). Aug 1972. 32p. NTIS (U.S. Sales Only).

A charge-neutral cylindrical plasma with radius of the order of the ion Lamor radius is considered, and eigenfrequencies are calculated for an arbitrary normalized density $\omega_{pi}^2/\omega_{ci}^2$ of up to $10^3$. It is found that there exist convenient modes for rf plugging and heating whose frequencies are of order $\omega_{ci}$. (auth)

**23740** (IPPJ-134) AZBEL–KANER RESONANCE IN GASEOUS PLASMAS. Minami, K. (Nagoya Univ. (Japan). Inst. of Plasma Physics). Jul 1972. 14p. NTIS (U.S. Sales Only).

The cyclotron resonance of ordinary electromagnetic fields in dense gaseous plasmas is analyzed. The phenomenon is similar to Azbel–Kaner resonance in cryogenic metals. The collisionless absorption of electromagnetic field by electrons and the propagation of slow electromagnetic waves in a dense plasma are investigated in some detail. Numerical calculations of refractive indices of ordinary waves are shown for a wide range of plasma parameters. (auth)

**23741** (IPPJ-136) NONLINEAR MODULATION OF ELECTROMAGNETIC WAVES IN A PLANE-BOUNDED PLASMA. Van Dam, J. W. (Nagoya Univ. (Japan). Inst. of Plasma Physics). Aug 1972. 23p. NTIS (U.S. Sales Only).

The extension to two dimensions of the reductive perturbation method developed by Taniuti et al. is the first discussed and then applied to the problem of electromagnetic waves propagating in a cold electronic plasma bounded by two conducting planes. The behavior of the amplitude modulation is found to be governed by a nonlinear Schroedinger equation, from which the stability of the wave can be determined in some limiting cases. (auth)

**23742** (ITF-72-136-P) PROPAGATION AND TRANSFORMATION OF WAVES IN A NONHOMOGENEOUS MAGNETICALLY ACTIVE PLASMA AT FREQUENCIES LESS THAN THE ELECTRON CYCLOTRON FREQUENCY. Kopecky, V. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1972. 14p. (In Russian). Dep. NTIS (U. S. Sales Only).

Propagation of waves in a weakly nonhomogeneous magnetically active plasma is considered. The density gradient is assumed to be perpendicular to an external magnetic field. The wave frequency $\omega$ is less than the electron cyclotron frequency $\omega_c$, and $k_z c/\omega > 1$ ($k_z$ is the wave vector component in the direction of a magnetic field). It is found that, in the high-density range, electrostatic waves transform into whistlers. (auth)

**23743** NONLINEAR DAMPING OF A PLASMA MODE. Nandan, R.; Pocobelli, G. (Saskatchewan Univ., Saskatoon). J. Plasma Phys.; 8: No. 2, 175-182(Oct 1972).

A theory of the nonlinear damping of a plasma mode based on a solution of the Vlasov–Poisson system is presented. The formulation is exempt from the separation of the particles into "resonant" and "nonresonant," and is valid for ion as well as for electron modes. The effect of the damping of the mode on particle motion is taken into account. A number of small new shifts in the damping of a plasma mode in general is obtained, including contributions from the second derivative of the stationary distribution function. (auth)

**23744** SHORT-LIFE MODE OF ELECTROSTATIC ELECTRON–CYCLOTRON HARMONIC WAVES. Oya, H. (Kyoto Univ.). J. Plasma Phys.; 8: No. 2, 183-196(Oct 1972).

Dispersion curves of electrostatic electron cyclotron harmonic waves are calculated numerically for a case of real angular frequency and complex wave vector that is pertinent for a case of pulsed short dipole excitation of plasma waves. Oblique propagation with respect to the ambient magnetic field direction is considered. The energy propagates in opposite directions in two modes, and the waves are always subjected to thermal damping. (auth)

**23745** TOTAL REFLECTION OF A PLANE WAVE BY A SEMI-INFINITE RANDOM MEDIUM. Sulem, P. L.; Frisch, U. (Observatoire, Nice). J. Plasma Phys.; 8: No. 2, 217-229 (Oct 1972).

An exact result in the theory of wave propagation in random media is presented. Using the ergodic theory of dynamical systems it is shown that a semi-infinite, one-dimensional random medium is totally reflecting. A direct numerical study shows that the mean reflection coefficient converges exponentially to one. (auth)

**23746** SELF-CONSISTENT ELECTROMAGNETIC WAVES IN RELATIVISTIC VLASOV PLASMAS. Winkles, B. B. Knoxville, TN; Univ. of Tennessee (1972). 81p. University Microfilms Order No. 73-2514.

Thesis (Ph.D.).

The relativistic Vlasov–Maxwell equations are used as a basis for treating nonlinear electromagnetic waves propagating in a uniform unbounded plasma. As is well known, the linear theory of such waves indicates that they are superluminous, i.e., they propagate at phase velocities greater than the vacuum velocity of light, c. To carry out the nonlinear calculation, it is first shown that the treatment of these waves can be greatly simplified by making a Lorentz transformation to a new reference frame in which the spatial variable no longer appears. Working in this new frame, self-consistent solutions of the relativistic Vlasov–Maxwell equations can be constructed. These solutions correspond to nonlinear traveling waves in a finite-temperature plasma, and it is shown that they reduce to the usual linear waves in the small-amplitude limit. A particular example is considered in which the nonlinear waves propagate through a relativistic Maxwellian plasma, and it is shown that a pure transverse wave cannot exist in such a case, but that a small coupled longitudinal field is necessary for self-consistency. Other nonlinear effects are the appearance of harmonics and a small shift in the fundamental frequency. These effects are evaluated correct to second order in the transverse field amplitude, obtaining a nonlinear dispersion relation and an expression for the relative energy in the coupled longitudinal field. In addition to the electromagnetic waves, there is also a class of longitudinal plasma oscillations that are superluminous, and these can be investigated by the same method. The case of a relativistic Maxwellian plasma is again considered, and a nonlinear dispersion derived. (Diss. Abstr. Int., B)

**23747** THICKNESS OF PERPENDICULAR COLLISIONLESS SHOCKS IN A HOT PLASMA. Cairns, R. A. (Saint Andrews Univ., Scotland). J. Plasma Phys.; 8: No. 2, 137-142(Oct 1972).

The characteristic length for the growth of magnetic field in a laminar wave front, propagating perpendicular to an external magnetic field, is found by linearizing about the upstream state as a function of the ratio of ion pressure to magnetic pressure. The scaling is in good agreement with the observed scaling of turbulent shocks, suggesting that for such shocks the shock thickness is closely related to that of the corresponding laminar pulse. (auth)

**23748** DAMPING OF AN ION-ACOUSTIC WAVE IN A WEAKLY IONIZED PLASMA. Cussenot, J. R.; Fabry, M.; Richard, M. (Univ., Nancy). Plasma Phys.; 15: No. 1, 1-4(Jan 1973). (In French).

In a low density cesium plasma spatial propagation of ion waves in the presence of collisions is investigated. Theoretical and experimental results are compared and indicate collisional and Landau damping. (auth)

**23749** NONLINEAR MODE–MODE COUPLING OF ALFVEN WAVES IN THE INTERSTELLAR MEDIUM. Fu, K. Y. (Univ. of Chicago). Plasma Phys.; 15: No. 1, 57-76(Jan 1973).

A set of differential equations is set up to describe the temporal and spatial evolution of transverse and longitudinal waves under mode–mode coupling in a relativistic plasma embedded in an ambient magnetic field. The plasma consists of immobile protons, thermal electrons, and cosmic-ray protons. An Alfven wave couples with another transverse and one longitudinal wave. The temporal mode–mode coupling effects on the nonlinear behavior of the Alfven wave are examined. Under certain conditions, it is found that the linear instability of the Alfven wave is "quenched". (auth)

**23750** HARMONIC GENERATION IN AN INHOMOGENEOUS AND NONUNIFORMLY MAGNETIZED PLASMA. Cano, R.; Fidone, I.; Schwartz, M. J.; Zanfagna, B. (CEN, Fontenay-aux Roses, France). Plasma Phys.; 15: No. 1, 81-84(Jan 1973).

An experiment is described in which an incident extraordinary wave, launched into an inhomogeneous plasma in a magnetic field, generates harmonic emission at the upper hybrid and cyclotron frequencies which is spatially localized. Variations in, and spatial origins of, the radiated harmonic power are discussed. (UK)

**23751** SPECIFIC FEATURE OF SURFACE WAVES AT THE BOUNDARY OF INHOMOGENEOUS PLASMA. Demchenko, V. V.; Hussein, A. M. (Atomic Energy Commission, Cairo). Plasma Phys.; 15: No. 1, 84-86(Jan 1973).

The effect of a longitudinal plasma inhomogeneity on the propagation of electrostatic surface waves along a sharp interface between isotropic plasma and vacuum is investigated. It is found that, provided the density gradient is small, the surface wave does not suffer reflection. (UK)

**23752** STRONG HELICON FREQUENCY TURBULENCE OF A PLASMA. Vainshtein, S. I. (Siberian Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Irkutsk, USSR). Zh. Eksp. Teor. Fiz.; 64: No. 1, 139-145(Jan 1973). (In Russian).

An analogy is drawn between hydrodynamic turbulence and turbulence of a collisionless plasma with frequencies between the ion and electron cyclotron frequency; the ions are assumed to be fixed and the electrons drift in crossed (self-consistent) random fields. The equation set in this case may be reduced to a single equation for the magnetic field H with a structure close to that of the equation for the velocity field. By applying the closure hypothesis one can demonstrate the presence of spectral transfer in the range of large wave numbers. A magnetic field pulsation spectrum $\sim k^{-7/3}$ can be obtained by aid of the Kolmogorov hypothesis. A similar situation may arise in a collision plasma with a strong Hall current and possibly in metals. The microcurrent power spectrum or, what is the same, the pulsation current for the electron velocity field is derived from the Maxwell equations and the spectral dependence of H. (auth)

**23753** ANOMALOUS NONLINEAR DISSIPATION OF HIGH-FREQUENCY RADIO WAVES. Silin, V. P. (Lebedev Inst. of Physics, Moscow). Usp. Fiz. Nauk; 108: No. 4, 625-654(Dec 1972). (In Russian).

The theory of parametric instability of plasma in an electromagnetic wave field, and theories of anomalous high-frequency conduction of a parametric unstable plasma are discussed. Experimental investigations of the anomalous nonlinear dissipation of high-frequency radio waves in a parametric unstable plasma, in which the frequency ranged from about $4 \times 10^{9}$ to $11 \times 10^{19}$ $\sec^{-1}$, are reviewed. The formation of fast electrons from the interaction of hf waves and plasma is noted. Parametric resonance in a plasma in a powerful magnetic field and anomalous dissipation of electromagnetic waves at frequencies near the Langmuir electron frequencies are considered. (63 references.) (KSW)

# PHYSICS (RADIATION AND SHIELDING)

## Radiation Physics

**23754** (NRCN-275) EXACT MEASUREMENT OF ABSORPTION COEFFICIENTS OF GAMMA RAYS AT THE 7.5-MeV REGION. Wand, Y. (Israel Atomic Energy Commission, Beersheba. Nuclear Research Center-Negev; Weizmann Inst. of Science, Rehovoth (Israel)). Sep 1970. 79p. (In Hebrew). INIS.

Thesis.

The absorption coefficients of $\gamma$ rays were measured by a new method which uses nuclear resonance scattering to analyze the ray passing through the absorber. An energy definition of 20 eV is obtained; thus avoiding the problems of scattered photons that undergo interaction with the absorber and the counter; there was no need for collimators. Absorption coefficients of 18 elements, from $Z = 4$ to $Z = 92$ were measured at 7.279 and 7.646 MeV. The accuracy of the values obtained equals, and is sometimes better, than previous experimental values. The results correspond to previous results and to values taken from theoretical tables, within their error range. However, as from a medium value for Z the results are higher than the theoretical values, and this deviation grows with Z and E. As this is a systematic deviation, there might be some inaccuracy in the calculation of one of the processes in the absorbing cross section. (INIS)

**23755** TWO-CENTER CALCULATIONS FOR X-RAY SCATTERING. Bentley, J.; Stewart, R. F. (Carnegie-Mellon Univ., Pittsburgh). J. Comput. Phys.; 11: No. 1, 127-145(Jan 1973).

An analytical procedure for the evaluation of two-center integrals in x-ray scattering calculations was developed. The scattering potential is represented in prolate spheriodal coordinates. The plane wave operator is expanded in spheroidal wave functions. All integrals are evaluated analytically with the aid of stable recursion relations. It is found that the several infinite sums involved are rapidly convergent, so that a practical computational method is at hand. The method is illustrated with a calculation of molecular scattering factor for CH from a near Hartree-Fock wavefunction comprised of an extended basis set of Slater-type orbitals. The coherent x-ray scattering intensity of $H_2$ was computed from a natural spin orbital expansion of the exact electronic wavefunction for the $^1\Sigma_g^+$ state of $H_2$. (auth)

**23756** INVESTIGATION OF GAMMA-IRRADIATION DOSE-FIELDS IN THE REACTION VOLUME OF PLANAR INDUSTRIAL IRRADIATORS SUITABLE FOR RADIATION MODIFICATION OF POLYMER MATERIALS ON RADIATION LOOPS. Kal'kis, V. Ya.; Dolatsis, Ya. A.; Rayavee, E. L. (Inst. of Wood Chemistry, Riga). Latv. PSR Zinat. Akad. Vestis, Fiz. Teh. Zinat. Ser.; No. 6, 9-15 (1972). (In Russian).

Experimental data on the characteristics of gamma-irradiation dose fields in the reaction volumes of large planar irradiator loops with regard to gamma-quanta multiple dissipation in the substance filling the volume are listed. The expediency of the application of parallel planar irradiators of 2.5 × 10 m size with a 1.4 m distance between the planes is shown. (auth)

**23757** ESTIMATION OF PERCENT-DEPTH-DOSE DISTRIBUTION IN SURFACE LAYER. 2. Betatron Electrons. Okamoto, S.; Amino, S.; Abe, K.; Nishio, H.; Shintani, Y. (Tokyo Medical Coll.). Tokyo Ika Daigaku Zasshi; 30: No. 4, 351-356(Jul 1972). (In Japanese).

The percent depth dose distribution in a simulated layer was estimated for betatron electrons with film method. Films were set on and between the layer of the pile-up of polystyrene plates of 1 mm thickness. Following results were obtained by this convenient method. Percent surface dose was 70 to 80% without any therapy cone and scatterer, and it was 80 to 90% with practical cone and scatterer in use. Variation in the percent surface dose with electron energy was practically not visible, in actual therapy conditions. Percent surface dose was increasing by more than 20% with Mix-DP inserted collimator. Present method was also applicable to the measurement of the percent depth dose distribution in a boundary layer. (auth)

**23758** STOPPING POWER OF ATOMIC MATTER FOR RELATIVISTIC IONS, MESONS, ELECTRONS, AND POSITRONS. Gould, R. J. (Univ. of California, San Diego, La Jolla). Physica; 62: No. 4, 555-564(15 Dec 1972).

The Born-approximation energy-loss formulas are derived for fast charged particles traversing matter and losing energy by excitation and ionization of atomic species. Bethe's results are obtained in an elementary, but more rigorous, derivation which also makes use of some recent work by the author on the corresponding stopping-power problem for a plasma. The formulas for the atomic and plasma problems are compared and the effects of magnetic interactions, retardation, and electron spin are discussed briefly. It is shown that in the computation of the stopping power, it is necessary to introduce and sum contributions from three momentum-transfer domains "very small," "small," and "large". In Bethe's formula for heavy ions, half of the additive (to the logarithmic factor) term $-\beta^2$ results from the very small momentum transfers and arises from essentially classical effects (retardation and magnetic interactions not involving spin); the other half arises from the contribution of the largest momentum transfers and is due to electron spin. In the stopping-power formulas for electrons and positrons the results are given in terms of an arbitrary maximum fractional energy loss. (auth)

**23759** LOW-ENERGY COMPONENTS OF SCATTERED GAMMA RADIATION. 2. Calculation of the Energy Spectra of Reflected Gamma Radiation by Monte Carlo Method. Minato, S. (Government Industrial Research Inst., Nagoya, Japan). Nagoya Kogyo Gijutsu Shikensho Hokoku; 21: No. 7, 176-180(Jul 1972). (In Japanese).

Reflection spectra of gamma rays scattered several times in a medium were calculated by the Monte Carlo method. Dependences of the spectra on the source energy, the thickness of a medium and the atomic number of the medium were studied. Shapes of high-energy components of the reflection spectra were found to be considerably different from those for the case of transmission. On the other hand, shapes of low-energy components were quite similar to those for the case of transmission. Thus, the spectrum had a peak in the low-energy region. The energy corresponding to the peak was barely dependent on the source energy or the thickness of the medium. However, it was strongly dependent on the atomic number of the medium. Dependence of the spectra on the spectra on the number of scatterings was also studied. (auth)

**23760** GAMMA-IRRADIATION DOSE-FIELD INVESTIGATION IN THE REACTION VOLUME OF AN INDUSTRIAL CYLINDRICAL IRRADIATOR OF RADIATION LOOPS. Kal'kis, V. Ya.; Dolatsis, Ya. A.; Rayavee, E. L. (Inst. of Wood Chemistry, Riga). Latv. PSR Zinat. Akad. Vestis, Fiz. Teh. Zinat. Ser.; No. 6, 16-23(1972). (In Russian).

Experimental data showing the characteristics of gamma-irradiation dose field in the reaction volume of large cylindrical irradiators of radiation loops are presented. The value of the contribution of gamma-quanta multiple scattering to the absorption capacity in water and wood is shown. The optimum irradiator sizes are observed to be as follows: the diameters of double cylinders equal 30 and 70 cm, the height being of no less than 150 cm. (auth)

**23761** MEAN EXCITATION ENERGIES OF SEVERAL COMPOUNDS AND MIXTURES. Porter, L. E.; Shepard, C. L. (Univ. of Montana, Missoula). Nucl. Instrum. Methods; 107: No. 1, 45-48(15 Feb 1973).

Previously measured stopping powers of several hydrocarbon compounds and mixtures have been fitted with the Bichsel energy loss computer code to determine mean excitation energies. The best fit values differ by as much as 14% from the corresponding calculated values based on an assumed additivity of stopping effects, although the average deviation is only 2%. (auth)

**23762** COMPTON SCATTERING FROM A MAXWELLIAN DISTRIBUTION OF ELECTRONS IN THE DISCRETE $S_n$ METHOD. Stephan, B. G. (Air Force Weapons Lab., Kirtland AFB, NM); Bridgman, C. J. J. Comput. Phys.; 11: No. 2, 269-295(Feb 1973).

An effort is summarized which calculated group-averaged Legendre coefficients to numerically represent the scattering kernel for x-ray scattering from a relativistic Maxwellian distribution of electrons in a multigroup discrete $S_n$ treatment of the equation of radiative transfer. An ordinary four-term Legendre polynomial expansion of the scattering kernel was used in the study. Ten sets of 134-group-averaged Wien weighted equilibrium cross section coefficients were calculated for electron temperatures between 0.5 and 20 keV, with photon energies between 0.05 and 400 keV. The first Legendre coefficients satisfy conservation and detailed balance at equilibrium neglecting induced effects. These 134-group cross sections can be collapsed to any desired few-group cross section sets using any appropriate weighting function and are suitable for use in x-ray transport studies using a discrete $S_n$ transport code. (auth)

**23763** TOTAL ELECTRON BACKSCATTER AND BACK-EMISSION YIELDS FROM METALS BOMBARDED AT SEVERAL ANGLES BY 0.4 TO 1.4 MeV ELECTRONS. Frederickson, A. R.; Burke, E. A. (Air Force Cambridge Research Labs., Bedford, MA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 160-166(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

Total high energy electron backscatter yields and low energy secondary electron yields have been measured for aluminum, copper and tantalum. Primary high energy electrons were incident at angles of 0°, 15°, 30°, 45°, 60°, and 75° from the surface normal. A new experimental measuring apparatus has been developed and tested to measure total electron yields from irradiated materials. This device is relatively free of the problems associated with electron emission from the device itself. (auth)

**23764** ABSOLUTE YIELDS OF X-RAY INDUCED PHOTO-EMISSION FROM METALS. Bradford, J. N. (Air Force Cambridge Research Labs., Bedford, MA). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 167-171 (Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707-.

Absolute electron yields from tantalum, molybdenum, copper and aluminum have been measured for several x-ray bombarding geometries. The photon spectra used were derived from filtered bremsstrahlung generated in a tungsten anode at 50 kV, constant potential. The electron spectra were measured by a cylindrical electrostatic analyzer with a secondary emission detector. The spectra exhibit both Auger and scattered photoelectrons. (auth)

**23765** STRAGGLING OF RELATIVISTIC CHARGED PARTICLES: CORRECTIONS TO THE LANDAU-VAVILOV STRAGGLING FUNCTIONS IN THE HYDROGENIC WAVE-FUNCTION APPROXIMATIONS. Bichsel, H.; Yu, Simon (Univ. of Washington, Seattle). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 172-174(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, USA (24 Jul 1972).

See CONF-720707-.

Corrections to the Landau-Vavilov straggling functions are given for relativistic charged incident particles. The calculation of the correction term is based on (1) the differential cross section for relativistic particles given by Bethe, and (2) a heavy hydrogen model for heavy atoms. (auth)

## Radiation Source Calibration and Standardization

**23766** STATE PRIMARY STANDARD OF THE UNIT OF NEUTRON FLUX. Yaritsyna, I. A.; Shchebolev, V. T.; Fominykh, V. I.; Stukov, G. M. Meas. Tech. (USSR) (Engl. Transl.); 15: No. 8, 1139-1143(Aug 1972).

Translated from Izmer. Tekh.; 15: No. 8, 8-11(Aug 1972).

Three experimental set-up for the standard measurement of neutron flux are described. The UEN-1 standard equipment utilized the associated particle techniques to measure neutrons from the $T(d,n)^4He$ reaction. The UEN-2 standard equipment comprises a manganese sulfate bath, and the UEN-3 standard equipment consists of gold activation foils in a water moderator. International comparisons using these three set-ups are discussed. (WHK)

## Shielding Calculations and Experiments

*Refer also to abstract 23334.*

**23767** (ABS-TUH-1066) INVESTIGATIONS ON RADIATION ATTENUATION IN SHIELDS WITH CONCRETE-EMBEDDED CONDUITS. Futtermenger, W. (Technische Universitaet, Hanover (West Germany)). Nov 1970. 5p. (In German). INIS.

Results are presented on $\gamma$-radiation propagation in curved iron ducts embedded in concrete. They were obtained for radiations with E = 660 keV ($^{137}$Cs) in ducts with 45° and 90° curvatures. Because of the especially high attenuation factors and thus low dose rates, the sweep radiation had to be suppressed which originates from the source radiation. (auth)

**23768** (KFKI-72-67) CALCULATION AND COMPARISON OF LEAKAGE NEUTRON SPECTRA. Makra, S.; Palfalvi, J.; Zarand, P. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). Nov 1972. 21p. (CONF-721203-11; SM-167/29). Dep. NTIS (U. S. Sales Only) $3.25.

From Symposium on neutron monitoring for radiation protection purposes; Vienna, Austria (11 Dec 1972).

Spectra of monoenergetic, fission and reactor sources after passing through various shields were calculated and compared with literature data. The following shields were considered: iron, from 30 to 180 cm thickness, and polythene and borated polythene, from 5 to 45 cm thickness. The object of the work is to determine the extent of agreement between spectra obtained in different laboratories by various calculation or measuring techniques and to investigate the effect on leakage spectra of different parameters, such as the measurement or calculation geometry, input spectra, shield composition, etc. (auth)

**23769** IONIZATION LOSSES OF HEAVY NONRELATIVISTIC PARTICLES IN MATTER. Remizovich, V. S. (Moscow Engineering-Physics Inst.). Zh. Eksp. Teor. Fiz., 63: No. 5, 1599-1608(Nov 1972). (In Russian).

Traversal of matter by a wide beam of fast heavy nonrelativistic particles is considered. The exact energy and depth distribution function is found without assuming smallness of energy losses when deflections due to multiple scattering can be neglected. The range distribution of heavy particles in matter is obtained. A simple approximate expression for the distribution function is obtained which is valid down to depths almost equal to the total range. The limits of applicability of the results are investigated. (auth)

**23770** DYNAMIC EFFECT ON PASSAGE OF A CHARGED PARTICLE BEAM THROUGH SOLID BODIES. Akhiezer, I. A.; Lazurik El'tsufin, V. T. (Kharkov State Univ.). Zh. Eksp. Teor. Fiz.; 63: No. 5, 1776-1779(Nov 1972). (In Russian).

Dynamic loads in a solid body due to traversal of charged particle beams are determined. It is shown that at not very high energies the loads linearly increase with growth of beam energy. At high energies (up to several hundreds of MeV) the loads are independent of energy in the case of an electron (positron) beam and decreases with increase of energy in the case of a proton beam. An experimental verification of the theory by measuring the amplitude of sound excited by the beam is proposed. (auth)

**23771** ZASHCHITA OT IONIZIRUYUSHCHIKH IZLUCHENII. Spravochnik, Izdanie Vtoroe Pererabotannoe i Dopolnennoe. (Protection from Ionizing Radiation. Second Edition, Revised and Enlarged). Kimel, L. R.; Mashkovich, V. P. Moscow; Atomizdat (1972). 312p.

A large number of tables of data and graphs are presented to the purpose of facilitating the calculation of shielding in connection with work with radioactive substances, including gamma, neutron alpha, and beta radiation or albedo. Tolerance levels of ionizing radiations are discussed in detail. 193 references. (KSW)

**23772** HALF-VALUE THICKNESSES OF ORDINARY CONCRETE FOR NEUTRONS FROM CYCLOTRON TARGETS. Butler, H. M.; Wallace, K. M.; Fulmer, C. B. (Oak Ridge National Lab., TN). Health Phys.; 24: No. 4, 438-439(Apr 1973).

Half-value thicknesses of ordinary concrete were measured for the attenuation of fast neutrons from cyclotron beam targets with incident projectile energies up to 100 MeV. The results are tabulated and indicate a half-value thickness from a variety of beam particle-target combinations from 9 to 10.5 cm with uncertainties of ±5%. The results indicate slightly larger half-value thicknesses for neutron spectra produced from carbon and aluminum targets than for copper and tantalum which suggests that neutrons from direct nuclear reactions are more probable in the lighter element targets. (UK)

**23773** CALCULATIONS OF THE TRANSPORT OF NEUTRONS AND SECONDARY GAMMA RAYS THROUGH CONCRETE FOR INCIDENT NEUTRONS IN THE ENERGY RANGE 15 TO 75 MeV. Roussin, R. W.; Alsmiller, R. G. Jr.; Barish, J. (Oak Ridge National Lab., TN). Nucl. Eng. Des.; 24: No. 2, 250-257(1973).

Earlier work by Alsmiller et al. considered coupled neutron and secondary-gamma-ray transport through a thick shield of silicon dioxide with 5% water by weight for neutron sources with energies of 50, 100, 200, 300, and 400 MeV. In that work, the approximation was made that gamma rays were produced only by neutron capture. In the present work, coupled neutron and secondary-gamma-ray transport through a thick shield of concrete for neutron sources with energies of 15, 25, and 75 MeV is considered. In this study, gamma-ray production for all interactions involving neutrons with energies up to 15 MeV was included; i.e., the approximation made here is that gamma-ray production can be neglected for interactions by neutrons with energies >15 MeV. For incident neutron energies of 15, 25, 50, and 75 MeV, results of total and gamma-ray dose equivalents are given as a function of depth into the slab. For the 50- and 75-MeV incident neutron energies, the gamma-ray dose equivalent was found to be no more than 5% of the total dose equivalent at all depths considered (≤1500 g/cm$^2$). For the 15- and 25-MeV incident neutron energies, however, the gamma-ray dose equivalent dominates at greater depths into the slab. A conservative estimate of the effect of including gamma rays produced in interactions with neutrons of energies >15 MeV indicates that the calculated total dose equivalent would increase by no more than 5%. (auth)

# PHYSICS (SOLID-STATE)

**23774** (ORNL-4861) SOLID STATE DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING DECEMBER 31, 1972. (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 136p. Dep. NTIS. $5.45.

Brief (~half-page) summaries of specific topics are presented under the following broad headings: radiation damage; surface studies, diffraction, and channeling; lattice dynamics; magnetic properties; electronic structure and spectroscopy; low-temperature properties; research materials; and experimental equipment and new techniques. Many of the summaries are abstracts of papers that have been or will be published. Also, a final section is devoted to publications, papers, patents seminars, scientific professional activities, and personnel changes. For the annual report for the preceding year, see ORNL-4779. (LMT)

## Radiation Effects

*Refer also to abstracts 22174, 22555, 22556, 22574, 22576, 22872, 22987, and 22989.*

**23775** (AD-749006) COOPERATIVE RADIATION EFFECTS SIMULATION PROGRAM. Semiannual Progress Report, 1 November 1971–30 April 1972. Steele, L. E.; Wolicki, E. A. (Naval Research Lab., Washington, D. C.). Aug 1972. 68p. (NRL-MR-2484). NTIS.

The facilities and techniques for simulating two phenomena, void formation and helium production in structural metals, were developed. Important progress was made in radiation-damage theory, especially the theory of energy deposition as related to the simulation of neutron damage by ion bombardment. In addition, transport theory was investigated for potential in this study. (auth)

**23776** (BNWL-SA-4047) ORDERED DEFECT STRUCTURES IN IRRADIATED METALS. Kulcinski, G. L.; Brimhall, J. L. (Battelle Pacific Northwest Labs., Richland, Wash.). 1971. Contract AT(45-1)-1830. 13p. (CONF-710917-3). Dep. NTIS $3.00.

From Seminar on radiation effects in metals and structural materials; Kyoto, Japan (28 Sep 1971).

Examples are presented of ordered loop and void structures in pure metals (Ni bombarded by 5-MeV Ni or 6-MeV Se ions, and Mo bombarded by 7.5-MeV Ta ions). A brief review is also given of information on ordered void structures; data on the ratio of equilibrium spacing to the void radius are tabulated. (23 references). (DLC)

**23777** (CEA-CONF-2113) FORMATION OF CAVITIES IN NICKEL AND SOME AUSTENITIC STEELS IRRADIATED BY MEDIUM-ENERGY HEAVY IONS. Azam, N.; Le Naour, L. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 25 Sep 1972. 23p. (In French). (CONF-721063-1; SMG-72/1600). Dep. NTIS (U. S. Sales Only).

From Autumn Meeting on Metallurgy; Chatenay-Malabry, France (2 Oct 1972).

Ionic bombardment causes, in several hours, effects in metals comparable to those observed in a reactor after several years. In order to compare the effects of ionic and neutron bombardment, high-purity Ni and some austenitic steels (304, 347, and 316 L) were irradiated with 500-MeV $Ni^+$ ions. The effects of temperature, preliminary charging with He, and dose were determined. Comparison of results with reactor irradiation indicate that, qualitatively, the phenomena are similar. Differences appear, however, from the quantitative viewpoint. The temperature of the swelling maximum is 100 to 200°C higher than in the case of neutrons. The determination of dose equivalence between ions and neutrons is difficult. Nevertheless, ionic bombardment remains a useful tool for studying the effect of certain parameters on swelling. The technique could be applied to other irradiation effects. (JSR)

**23778** (CEA-CONF-2115) STUDY OF SWELLING OF METALS UNDER IRRADIATION BY SMALL-ANGLE SCATTERING OF X RAYS: APPLICATION TO ALUMINUM. Baron, J.-L.; Cadalbert, R. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 25 Sep 1972. 16p. (In French). (CONF-721063-2; SMG-72/1601). Dep. NTIS (U. S. Sales Only).

From Autumn Meeting on Metallurgy; Chatenay-Malabry, France (2 Oct 1972).

The use of small-angle scattering of x rays to study the swelling of metals under irradiation was applied to Al irradiated by fast neutrons. The principle of the method is that the beam of incident x rays, very fine and geometrically well defined, traverses the material to be studied. If this material shows internal electron density fluctuations, a scattered radiation around the beam transmitted is observed and it can be recorded on film or measured with a counter. The experimental technique is described and the results are reported. The study of the scattered radiation makes it possible to enumerate the cavities present and to define the dimensional characteristics. The results obtained on high-purity Al irradiated by neutrons are in good agreement with those obtained by electron microscope. Small cavities difficult to observe or count with the electron microscope are observable with the small-angle scattering technique. (JSR)

**23779** (IAE-2200) FORMATION OF CLUSTERS OF DEFECTS DURING NEUTRON BOMBARDMENT TAKING ACCOUNT OF CASCADE OVERLAP. Al'tovskii, I. V. (Institut Atomnoi Energii, Moscow (USSR)). 1972. 11p. (In Russian). Dep. NTIS (U. S. Sales Only) $3.00.

Defect accumulation during overlapping of cascades was examined, allowing for the distribution of the irradiated volume of material according to the multiplicity of penetration by cascades of random energies at a random moment of time. On the basis of an isolated system of equations for the determination of the point defect concentration, while the defects are migrating during the intervals of time between cascades, and for the concentration of clusters interacting with point defects both at the time of congealing a cascade zone, and at the temperature of radiation, an expression was obtained for the average concentration of spherical, vacant clusters of a given diameter at an arbitrary moment of time of radiation and for a given energy spectrum of atoms forming the cascades and a prescribed temperature. During large radiation times the pore dimensions appeared to be proportional to the first power, and the volume to the third power of the radiation time. (tr-auth)

**23780** (KURRI-TR-103) RESEARCH ON RADIATION DAMAGE EMPLOYING NEW EXPERIMENTAL TECHNIQUES. Osamu, T.; Yoshida, H.; Nakagawa, M. (comps.) (Kyoto Univ. (Japan). Research Reactor Inst.). 1972. 58p. (In Japanese). Dep. NTIS (U. S. Sales Only).

This volume is a compilation of the papers presented at the conference with the theme "Research on Radiation Damage Employing New Experimental Techniques," held at the Reactor Research Institute of Kyoto University May 10-11, 1972. The papers can be generally classified into two groups. The first group includes those papers that discuss the introduction of comparatively new techniques such as the Moessbauer effect, positron decay, and channeling field ion microscope. The second group is concerned with those techniques that were developed some time ago but which have undergone certain refinements recently to enhance their precision and made possible the measurement of micro changes which were not possible before. Some representatives of this group are electron microscopy, thermal measurements, electrical resistance measurements, resonance absorption, and pulse techniques. The condensations of 13 papers are included. The program of the meeting and that of an auxiliary session on "Radiation Damage to Metals and Alloys" are appended. These two papers have the titles "Low Temperature Irradiation and Recovery Processes in Metals" and "Radiation Effects in Time Affected Alloys." (TTT)

**23781** (ORO-3912-20) COMPUTER EXPERIMENT STUDIES ON MECHANISMS FOR IRRADIATION-INDUCED DEFECT PRODUCTION AND ANNEALING PROCESSES. Progress Report, October 1, 1972–December 31, 1972. Beeler, J. R. Jr. (North Carolina State Univ., Raleigh). Jan 1973. Contract AT(40-1)-3912. 15p. Dep. NTIS $3.00.

Progress is reported on two new projects: (1) dependence of the displacement threshold energy in an fcc metal (gamma-iron) on crystallographic direction, and (2) an atomic collision cascade program (COLLIDE) for simulating damage production in ion-bombarded specimens. (DLC)

**23782** SPUTTERING OF GOLD BOMBARDED BY 20- TO 50-keV $Ar^+$ AND $Xe^+$ IONS. Nenadovic, T. M.; Fotiric, Z. B.; Dimitrijevic, T. S. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Surface Sci.; 33: No. 3, 607-616(Dec 1972).

The sputtering ratio from polycrystalline Au was measured as a function of ion energies. The gold specimens were bombarded with inert gas ions ($Ar^+$ and $Xe^+$) of energies from 20 to 50 keV. The coefficients of cathode sputtering were determined by gravimetric analysis of weight losses during the bombardment and by spectrophotometric analysis of gold deposit after being dissolved from the glass collector. Results are in good mutual agreement and in accordance with the values calculated from Roll's and Sigmund's theory. The intensity maximum of the particles sputtered from a single crystal ((100) plane) corresponds to the close-packed directions ([100]) for gold. Studies of the bombarded surfaces by the replica method show that a change in surface structure occurs during the bombardment. Nonuniform sputtering preferentially develops certain crystal faces, and the surface structure of each individual grain degenerates into an undulation sputtering structure. (auth)

**23783** ENERGY DISTRIBUTION OF SECONDARY ELECTRONS EMITTED BY InP AND GaP SUBJECTED TO 40-keV ARGON-ION BOMBARDMENT. Benazeth, C.; Viel, L.; Colombie, N. (Univ. Paul Sabatier, Toulouse). Surface Sci.; 32: No. 3, 618-622(Sep 1972). (In French).

The energy distributions N(E) of secondary electrons emitted from GaP and InP samples bombarded with 40-keV $Ar^+$ ions were studied by a retarding potential method and an electronic derivation. The spectra show beyond an intensive peak developed at 2 eV, a detailed spectrum between 80 and 140 eV. The analysis of this spectrum reveals Auger electrons corresponding to $L_{23}$(P) VV and $L_{23}M_{IV-V}$(Ga) V [or $L_{23}$(P) $N_{IV-V}$(In) V] transitions; moreover, peaks due to plasmon excitations and d band excitations can be distinguished. (auth)

**23784** IN-DEPTH PROFILES OF PHOSPHORUS-ION-IMPLANTED SILICON BY AUGER SPECTROSCOPY AND SECONDARY ION EMISSION. Morabito, J. M.; Tsai, J. C. (Bell Telephone Labs., Inc., Allentown, PA). Surface Sci.; 33: No. 2, 422-426(Nov 1972).

Measurements by Auger spectroscopy in combination with simultaneous in-situ ion sputtering (by 600-eV Ar ions) and secondary ion emission, were made to study the use of these techniques for obtaining ion-implanted concentration profiles. From the Auger data, a practical detectability of $\sim 5 \times 10^{19}$ atoms/$cm^3$ or $^1/_{200}$ of a monolayer surface sensitivity for an escape depth of 10 Å was found for P in Si. Results with the Cameca ion analyzer showed poor agreement with LSS theory using $^{31}P^+$ but good agreement using $^{47}PO^-$. A plot of the profile shows an exponential tail besides the gaussian distribution. The detectability limit is close to $1 \times 10^{18}$ atoms/$cm^3$; it can be improved to $\sim 10^{17}$ atoms/$cm^3$. (DLC)

**23785** MEANS OF OBTAINING UNIFORM SPUTTERING IN AN ION MICROPROBE. Blewer, R. S.; Guthrie, J. W. (Sandia Labs., Albuquerque, NM). Surface Sci.; 32: No. 3, 743-747 (Sep 1972).

It is shown that well-defined sputter craters of uniform depth can be formed on thin films using an ion microprobe mass analyzer (IMMA) without the need for rastering or apertures. This is done by the proper combination of primary beam-optics focus settings which, in turn, requires both a tuning sample and a means for observing the effect of tuning parameter changes on the sample during the sputtering process. Best results are obtained for a beam focal point below the surface (virtual focus) rather than above. Uniform sputter craters were produced in Er films. (DLC)

**23786** IMPURITY EFFECTS ON THE STRUCTURE OF AMORPHOUS SILICON AND GERMANIUM PREPARED IN VARIOUS WAYS. Moss, S. C. (Energy Conversion Devices, Inc., Troy, MI); Flynn, P.; Bauer, L. O. Phil. Mag.; 27: No. 2, 441-456(Feb 1973).

Thin-film transmission electron diffraction patterns from amorphous silicon, prepared by ion implantation, rf sputtering, and vapour deposition are strikingly similar in most details except in the exact position of the diffuse peaks. For high-purity silicon, either evaporated or ion-implanted, the first diffuse ring, for example, occurs consistently at a value of $s(=4\pi \sin \theta/\lambda)$ slightly lower than that of the (111) Bragg peak of the crystallized film. For sputtered films, this diffuse ring appears at a higher angle than the (111) peak both in thin-film electron diffraction and in x-ray scattering from thick films. The reversal is attributed to impurities, most probably oxygen or nitrogen. An analysis shows that the position of the diffuse peak in question can be correlated with the separation of second nearest-neighbours which is therefore deduced to be contracted in the impure samples. No changes in the diffraction pattern were observed on annealing, although the optical absorption edge moves to higher energies. Similar measurements on amorphous germanium films show little difference between the position of the first diffuse ring in evaporated and sputtered films; in both cases it occurs at a lower angle than does the (111) reflection of the crystallized samples. However, in severely oxygen-contaminated amorphous germanium, the diffuse peak shifts to lower angle with annealing while the absorption edge position shows a shift to higher energies. In germanium of a purity comparable with the sputtered silicon, there is a negligible change in position of shape of diffuse peaks on annealing although, as with silicon, there are still changes in optical absorption. (auth)

**23787** SPUTTERING MECHANISMS FOR AMORPHOUS AND POLYCRYSTALLINE SOLIDS. Tsong, I. S. T.; Barber, D. J. (Univ. of Essex, Eng.). J. Mater. Sci.; 8: No. 1, 123-135(Jan 1973).

The latest developments in the theory of sputtering of amorphous and polycrystalline targets are reviewed and comparison is made with available experimental data. Special attention is given to differences in the various theoretical approaches to the sputtering yield problem and the conclusions derived therefrom. (auth)

**23788** LOCALIZED VIBRATIONAL MODES OF A PERSISTANT DEFECT IN ION-IMPLANTED SiC. Patrick, L.; Choyke, W. J. (Westinghouse Research Labs., Pittsburgh). J. Phys. Chem. Solids; 34: No. 3, 565-567(Mar 1973).

The low-temperature luminescence spectrum of an intrinsic defect in ion-implanted cubic SiC reveals a number of high-energy localized modes. One has an energy of 164.7 meV, equivalent to the highest lattice frequency in diamond, and far above the 120.5-meV lattice limit of SiC. A carbon di-interstitial is a plausible model for the defect, which appears after a 1300°C anneal, and persists after a 1700°C anneal. (auth)

**23789** PROPERTIES OF SILICON IMPLANTED WITH BORON IONS THROUGH THERMAL SILICON DIOXIDE. Bauer, L. O.; MacPherson, M. R.; Robinson, A. T.; Dill, H. G. (Hughes Aircraft Co., Newport Beach, CA). Solid-State Electron.; 16: No. 3, 289-300(Mar 1973).

The properties of silicon implanted with boron ions through thermal $SiO_2$ films were studied using sheet resistivity measurements (corroborated by Hall data). Electrical properties for implants through 0.1 m of $SiO_2$, as compared to bare silicon, showed no unusual behavior as a function of anneal temperature. Sheet resistivity measurements as a function of $SiO_2$ thickness for fixed ion energy, and as a function of energy for fixed oxide thickness were made after 525 and 925°C anneals, for boron doses of $10^{13}$, $10^{14}$, and $10^{15}$ ions/$cm^2$. The profile of boron ions in $SiO_2$ is near Gaussian for the energy range investigated and the stopping power is 0 to 20% lower than the theoretical value currently in the literature. Considerations for device manufacture are discussed in light of the results. (auth)

**23790** RADIOLYSIS OF STRONTIUM FLUORIDE. Hayes, W.; Lambourn, R. F. (Oxford Univ.). J. Phys., C (London); 6: No. 1, 11-26(17 Jan 1973).

The colourability of $SrF_2$ at 4°K is shown to be comparable with that of KBr. However, the colourability falls sharply by a factor of about 5 at 34°K and a further fall occurs at 67°K. When the onset of $V_K$ motion begins at ~110°K, the colourability falls to a very low value and does not recover on raising the temperature to 300°K. X irradiation of $SrF_2$ at 77°K and lower temperatures produces F centers and $V_K$ centers; the number of H centers formed is always more than two orders of magnitude smaller than that of $V_K$ centers. The F band shows partly resolved structure and this is more extended for irradiation below 34°K than above. Bleaching with linearly polarized light induces dichroism in the F band. ENDOR measurements have been made on the F centers produced by irradiation below and above 34°K. It is suggested that the F band structure arises from association with interstitial fluorine ions (I) and that the decrease of colourability with increasing temperature is due to annealing of F center-interstitial (F–I) pairs of increasing separation. This annealing is associated with a corresponding destruction of $V_K$ centers. (auth)

**23791** COLOUR CENTERS IN STRONTIUM CHLORIDE. Hayes, W.; Lambourn, R. F.; Rangarajan, G.; Ritchie, I. M. (Oxford Univ.). J. Phys., C (London); 6: No. 1, 27-35(17 Jan 1973).

X irradiation of $SrCl_2$ at 77°K produces $V_K$ centers and F centers; H centers are not produced in observable concentration. A study of the effects of polarized bleaching light on the optical and EPR spectra shows that a $^2\Sigma - ^2\Sigma$ type transition of the $V_K$ centers occurs at 397 mn. The $V_K$ centers decay at 105°K with an activation energy of 0.251 eV. Some of the moving holes are trapped at lattice defect sites forming $V_{KA}$ centers. Only perturbed F centers are observed in appreciable concentration in the irradiated crystals. These centers were investigated by EPR and magneto-optical methods. The F band shows partly resolved structure with peaks at 580 and 667 nm. Dichroism induced in these peaks by bleaching with linearly polarized light shows that the symmetry of the perturbed F centers is close to trigonal. Complex thermal annealing effects of the F centers are observed. A final annealing stage occurs at 290°K with complete removal of F centers and $V_{KA}$ centers. (auth)

**23792** ELECTRONIC AND VIBRATIONAL SPECTRA OF FERRICYANIDE IONS DOPED IN NaCl AND KCl CRYSTALS. Jain, S. C.; Warrier, A. V. R.; Sehgal, H. K. (Indian Inst. of Tech., New Delhi). J. Phys., C (London); 6: No. 1, 193-200 (17 Jan 1973).

Ten absorption bands are observed in the electronic spectra of NaCl and KCl crystals doped with $Fe(CN)_6^{3-}$ ions in the range 50,000 to 20,000 cm$^{-1}$. Six of these bands are assigned to the ligand-to-metal charge-transfer transitions ($t_{1u}^6 t_{2g}^5 - t_{1u}^5 t_{2g}^6$ and $t_{1u}^5 t_{2g}^5 e_g^1$ and $a_{1g}^2 t_{2g}^5 - a_{1g}^1 t_{2g}^6$). The positions of these bands agree with those calculated using Dq = 1944 cm$^{-1}$, B = 623 cm$^{-1}$, and C = 3270 cm$^{-1}$ for $d^6$ configuration. The remaining four bands are assigned to crystal-field transitions for $d^5$ configuration and agree with the calculated peak positions for Dq = 3450 cm$^{-1}$, B = 700 cm$^{-1}$, and C = 2400 cm$^{-1}$. Vibration spectrum in the ($C \equiv N$) stretch region shows that the $Fe(CN)_6^{3-}$ ion is present predominantly in the $C_s$ site symmetry. The infrared spectrum also shows the presence of $Fe(CN)_6^{4-}$ ions in the as-grown crystal. On x irradiation, an infrared absorption line corresponding to $Fe(CN)_6^{5-}$ is also observed. (auth)

**23793** ELECTRON EMISSION FROM ALKALI HALIDES UNDER SOFT-X-RAY BOMBARDMENT. McDonald, I. R.; Lamki, A. M.; Delaney, C. F. G. (Trinity Coll., Dublin). J. Phys., D (London); 6: No. 1, 87-96(1 Jan 1973).

An account is given of a method of measuring the yield and statistical distribution of the number of secondary electrons emitted from films of certain alkali metal halides under soft x-ray bombardment. The results are interpreted in terms of a theoretical model which is partly based on a Monte Carlo calculation used previously to describe the passage of low-energy electrons through thin films. Numerical values for parameters characterizing the electron-emission process are compared with results of other workers. (auth)

**23794** ROLE OF EXCITON DIFFUSION IN THE ELECTRON-INDUCED SPUTTERING OF ALKALI HALIDES. Al Jammal, Y.; Pooley, D.; Townsend, P. D. (Sussex Univ., Brighton, Eng.). J. Phys., C (London); 6: No. 2, 247-254(31 Jan 1973).

The role of exciton diffusion in electron-induced sputtering of alkali metal halides is discussed. This diffusion allows excitons created some distance beneath the surface to contribute to sputtering and causes the sputtering efficiency to peak at a higher bombarding electron energy than would be expected if no diffusion occurred. Measurements of this peak energy for KI and KI containing 0.1% TlI indicate exciton diffusion ranges of 21 and 13 nm. In KI:Tl a reduction in sputtering efficiency and a lower peak energy are consistent with the model of exciton diffusion, the $Tl^+$ ions acting as recombination centers. The exciton trapping cross section of thallium ions which can be estimated in this model is comparable with the ionic size of $Tl^+$. (auth)

**23795** CHANNELING EFFECTS AND LATTICE DEFECTS. Mannami, M.; Oshiyama, T.; Kudo, H. (Kyoto Univ.). Oyo Butsuri; 41: No. 8, 884-890(Aug 1972). (In Japanese).

Channeling effect and lattice defects are reviewed. Motion of fast moving ions in crystals was simulated by Robinson and Oen, and by Beeler and Besco with electronic computers. Beeler and Besco obtained the number of displaced atoms $\nu(E)$ due to the ions of energy E and compared the energy dependence of atomic displacement effect K(E) with K(E) from cascade theory, in which K(E) was calculated from relation $\nu(E) = 1 + K(E) \times E/E_d$, where $E_d$ is atomic displacement energy. It was found that K(E) was remarkably reduced when the energy was above 5 keV, due to the channeling effect. Wide distribution of the displaced atoms, unproportionality of the number of displaced atoms to the dose of irradiation, and temperature dependence of $\nu(E)$ were also recognized. Two methods are used for the study of lattice defects. The one is a channeling arrangement method, and the other is a blocking arrangement method. Backscattered ions are commonly measured in both methods. The channeling arrangement, in which the direction of incident ion beams is parallel to crystal channel, is usually used. Probability of dechanneling is an important value for the study of the lattice defects. Analysis by simulation is in progress. Determination of the position of impurity atoms was performed by using the channeling effect. Blocking of alpha particles emitted from $^{222}Rn$ implanted in a tungsten single crystal was observed by Domeij et al. The backscattering of injected ions was also used for the determination of position. Distribution of the lattice defects was also studied by the channeling of ion. (Japan)

**23796** EFFECT OF ELECTRON IRRADIATION ON VOID FORMATION IN HELIUM-PRE-INJECTED ALUMINIUM FILMS. Rao, P.; Glowinski, L. D.; Ho, P. S. (Cornell Univ., Ithaca, NY) Phil. Mag.; 27: No. 2, 341-360(Feb 1973).

The effect of 200-kV electron irradiation on evaporated Al films pre-injected with 35-keV helium ions was studied. With a fluence of 1 × 10$^{15}$ ions/cm$^2$ of helium, the damage produced consisted of voids 30 to 40 Å in diameter and dislocation loops 200 Å in diameter. Such damage was observed to be enhanced by in-situ electron irradiation at room temperature ($\approx$0.3 $T_m$) with a flux of 1 × 10$^{19}$ electron/cm$^2$-sec. The enhancement was in the form of increased void number density and void volume in addition to increased interstitial dislocation loop density and loop area. This effect appeared to be temperature-dependent, since a decrease in void volume with a smaller increase in interstitial dislocation loop area was observed on electron irradiation at 100°C (0.4 $T_m$). The annealing of helium-pre-injected films, prior to electron irradiation, at 100°C resulted in a large increase in void volume accompanied by a slight decrease in dislocation loop number density and loop area although loop size increased. Interstitial loops are found to play an important role in void formation. The preferential removal of interstitials at these loops tends to reduce recombination of interstitials and vacancies produced by electron irradiation, thus creating a sufficient vacancy supersaturation to promote void growth. Positive identification of voids 30 to 40 Å diameter in Al was made using "through-the-focus" sequences of micrographs to determine change in void contrast. (auth)

**23797** LITHIUM DISTRIBUTION IN NEUTRON-IRRADIATED BORON SINGLE CRYSTALS. Born, E. (Technical Univ., Munich). Radiochim. Acta; 18: No. 1, 63-64(Dec 1972).

The Li distributions in B crystals were measured after irradiations at 400 and 600°C and compared with calculations. Experiment and calculation agree well for the irradiation temperature of 400°C, indicating that neither thermal diffusion nor radiation-enhanced diffusion are important. No gradient in the Li distribution was found in a 60-$\mu$m B crystal irradiated at 600°C. (DLC)

**23798** ION IMPLANTATION IN SEMICONDUCTORS. Part II. Damage Production and Annealing. Gibbons, J. F. (Stanford Univ., CA). Proc. IEEE (Inst. Elec. Electron. Eng.); 60: No. 9, 1062-1096(Sep 1972).

A review is presented of work that has been performed over the past several years in an effort to understand implantation-produced damage and its annealing characteristics, especially in silicon. A qualitative description of the damage produced by an implanted ion is presented, followed by a partial inventory of the basic defects found in ion-implanted silicon. The structure of individual damage clusters produced by both heavy and light ions is then described, and theoretical predictions are compared to a variety of experimental data. This is followed with a section on the depth distribution of defects and damage clusters; and the review is then concluded with a section on the annealing characteristics of implantation-produced damage. The development is organized to give primary emphasis to those facts and ideas that are essential for applications of ion implantation in the fabrication of MOS and junction devices in silicon. (50 figures, 64 references) (auth)

**23799** MECHANISM OF ACCELERATION OF MIGRATION OF METAL ATOMS UNDER THE INFLUENCE OF RADIATION. Dekhtyar, I. Ya.; Shalaev, A. M.; Adamenko, A. A. (Inst. of Metal Physics, Kiev). Metallofizika; No. 41, 63-67(1972). (In Russian).

A short review of the literature on the dependence of the diffusion coefficient on parameters of radioactive radiation is presented. The dependence of the forces of atomic bonds on the total of interactions of free and bound electrons was the basis of further experimentation with bombarding particles and atomic lattices of the irradiated metals. (28 references) (tr-auth)

**23800** HELIUM GAS BUBBLES IN VANADIUM. Heerschap, M.; Schueller, E.; Langevin, B.; Trapani, A. (Common Research Centre, Petten, Netherlands). J. Nucl. Mater.; 46: No. 2, 207-209 (Mar 1973).

Recrystallized V foils (99.987% pure) were implanted with $\alpha$ particles of energy varying from 3 to 2 MeV. Upon irradiation at 750°C, the bubbles nucleate preferentially at grain boundaries and dislocations, and they are perfect cuboids of average size 60 Å. After irradiation at room temperature and annealing at 750°C, a homogeneous distribution of 30-Å bubbles results. Cavities form at an irradiation temperature of 400°C. From the defocus appearance of the bubbles in electron microscopy, they are pure phase objects. (DLC)

**23801** RAFTING IN NEUTRON-IRRADIATED TUNGSTEN. Sikka, V. K.; Moteff, J. (Univ. of Cincinnati). J. Nucl. Mater.; 46: No. 2, 217-219(Mar 1973).

Results are reported on "raft" formation (small loop and/or black spot cluster agglomerates) in W irradiated by a fast neutron fluence of 10$^{22}$ n/cm$^2$ at 430 and 580°C. The rafts are of the pure edge type, and their thickness is ~80 Å at 430°C and ~100 Å at

580°C. The raft densities ($3.1 \times 10^9$ and $3.7 \times 10^9/\text{cm}^2$) are within a factor of two of the dislocation density ($\sim 2 \times 10^9/\text{cm}^2$) in the unirradiated material. Results suggest that rafts may result from preferential drift of free interstitials to dislocations, as well from glide and self-climb of loops. (DLC)

**23802** EFFECT OF CYCLOTRON-INJECTED HELIUM ON VOID-FORMATION CHARACTERISTICS OF TYPE 304 STAINLESS STEEL. Harkness, S. D.; Kestel, B. J.; McDonald, S. G. (Argonne National Lab., IL). J. Nucl. Mater.; 46: No. 2, 159-168 (Mar 1973).

Samples of Type 304 stainless steel were injected with helium by cyclotron bombardment to concentrations ranging between $1.1 \times 10^{-7}$ and $1 \times 10^{-4}$ ppMa. Following cyclotron injection, the samples were given a variety of heat treatments prior to insertion in EBR-II for irradiation at 450°C to a total dose of $1 \times 10^{21}$ n/cm$^2$. Samples that were not heat treated or that were annealed at 650°C following cyclotron injection formed few voids and dislocation loops after EBR-II irradiation. This behavior is apparently due to the precipitate clusters that were formed during the helium injection. These precipitates were analyzed by electron-microscopic techniques and found to have spherically symmetric strain fields that were of interstitial character. Samples that were annealed at 760°C following cyclotron injection formed a larger number density of both voids and dislocation loops than did the control sample after EBR-II irradiation. The void volume also exceeded that of the control. Clustering of the dislocation loop population near grain boundaries and precipitate particles was observed in the control and low-helium-concentration samples. (auth)

**23803** DEFECT DEVELOPMENT IN NEUTRON-IRRADIATED TYPE 316 STAINLESS STEEL. Brager, H. R.; Straalsund, J. L. (Hanford Engineering Development Lab., Richland, WA). J. Nucl. Mater.; 46: No. 2, 134-158(Mar 1973).

The effects of fast neutron irradiation on the defect development in unstressed solution-treated Type 316 stainless steel were investigated by transmission electron microscopy. The irradiation conditions convered the fluence range from 0.75 to $5.1 \times 10^{22}$ n/cm$^2$ ($E > 0.1$ MeV) and temperatures from 380 to 850°C. Empirical equations were developed relating the void volume, void number density, mean void size, Frank faulted loop diameter, Frank loop number density, and dislocation density with the neutron fluence and irradiation temperature. Void nucleation changes from homogeneous at low irradiation temperature ($\lesssim$400°C) to heterogeneous at higher temperatures in that voids are preferentially associated with irradiation-induced rod shaped precipitates. The void number density decreases while the void diameter increases with irradiation temperature. The total faulted loop line length per unit volume and dislocation density increases with fluence and decreases with temperature. The Frank loop diameter increases and number density decreases with temperature. The range of temperature in which Frank faulted loop formation occurs decreases with neutron fluence. 50 references, 17 figures. (auth)

**23804** INTERNAL FRICTION AND MODULUS ANOMALIES OF Al, IRRADIATED AND DEFORMED AT LOW TEMPERATURES. Fantozzi, G.; Fouquet, F.; Gobin, P. F. (Institut National des Sciences Appliquees, Villeurbanne, France). Mem. Sci. Rev. Met.; 69: No. 9, 641-652(Sep 1972). (In French).

The anelastic behavior of 99.999% pure Al irradiated in neutron beams having energies of greater than 1 MeV and deformed at low temperature was studied. Two manifestations of internal friction are considered: manifestations due to the intrinsic properties of dislocations (Bordoni relaxation); and manifestations due to the interaction between dislocations and point defects (P(B) and P(C) peaks). A brief description is given of the theory of Bordoni relaxation due to the thermally activated formation of double jogs and their diffusion. The primary and secondary characteristics of this relaxation are considered in the case of Al. Studies of the effects of work hardening, annealing, the amplitudes, and the effect of neutrons on these characteristics demonstrate a qualitative agreement between results and theory. The conditions under which P(B) and P(C) dislocation–point defect interactions occur are given and an interpretation of the P(C) peak is presented. (France)

**23805** OPTICAL PROPERTIES OF SILICON IRRADIATED WITH NEUTRONS. Koval, Yu. P.; Mordkovich, V. N.; Temper, E. M.; Kharchenko, V. A. Fiz. Tekh. Poluprov.; 6: No. 7, 1317-1322(Jul 1972). (In Russian).

The infrared absorption of n and p-type Si was studied after neutron irradiation at 60 to 250°C, the samples subsequently being isochronously annealed at 100 to 800°C. In addition to the well-known nonselective absorption near the 2- to 4-$\mu$ band and absorption in certain samples at 17 to 25 $\mu$, a further region of absorption occurred at 4.5 to 14.5 $\mu$, with a fine structure comprising some twenty subsidiary peaks. The relative intensities of the several forms of absorption depended on the conditions of irradiation. (Metals Abstr.)

**23806** ELECTRONIC TRANSPORT IN INSULATING FILMS. Johnson, W. C. (Princeton Univ., NJ). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS-19: No. 6, 33-40(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707–.

A brief review of various electronic transport processes in insulating films is given. The topics include a brief consideration of energy bands and the concepts of extended and localized states; the properties of traps with emphasis on Shockley–Reed theory; the space-charge limitation of currents for one-carrier injection; the bulk trap limitation of currents including hopping conduction, the Poole–Frenkel effect, and field emission from traps; and ionic conduction. (auth)

**23807** ENERGY DEPENDENCE OF DISPLACEMENT EFFECTS IN SEMICONDUCTORS. van Lint, V. A. J.; Leadon, R. E.; Colwell, J. F. (Gulf Radiation Tech., San Diego, CA), IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci.; NS–19: No. 6, 181-185(Dec 1972).

From Annual Conference on Nuclear and Space Radiation Effects; Seattle, Washington, United States of America (USA) (24 Jul 1972).

See CONF-720707–.

In a semiconductor, the formation of a space-charge region is a logical consequence of the creation of a defect cluster. The dependence of cluster size and defect density on neutron energy can be derived directly from neutron-scattering data and recoil range-energy relationships. The effect of clusters on macroscopic semiconductor properties (e.g., recombination rate, carrier removal) is more uncertain, but the shape of the dependence on cluster size is not strongly dependent on the constants used in the calculation. The relative effectiveness of 14- and 1-MeV neutrons before annealing is predicted to be significantly larger for recombination rate (factor of 2.7) than for carrier removal (factor of 1.7). The annealing process can decrease this difference. Moreover, it is possible that the time scale on which annealing proceeds can be different for the larger clusters produced by 14-MeV collisions. (WHK)

**23808** INTERNAL FRICTION PHENOMENON IN RELATION TO THE PROPERTIES OF POINT DEFECTS IN METALS. Moser, P.; Pichon, R. (CEN, Grenoble, France). J. Phys., F (London); 3: No. 2, 363-392(Feb 1973).

Point defects can give rise to anelastic and internal friction phenomena, if several specific conditions are fulfilled. Conversely, the observation of these phenomena gives very useful information concerning the defect concentration, mobility, and symmetry that are simultaneously detected. In metallurgical research, hetero-interstitial investigations, performed by means of these techniques, reveal the impurity affinities and the precipitation kinetics. In radiation-damage research, internal friction gives evidence of a free migrating defect in stage $I_E$ of bcc and hcp metals, and in stage III of nickel and copper. Close pairs of surprising stability are often mentioned. (auth)

**23809** DIRECT OBSERVATION OF POINT DEFECTS IN IRRADIATED OR QUENCHED METALS BY QUANTITATIVE FIELD ION MICROSCOPY. Seidman, D. N. (Cornell Univ., Ithaca, NY). J. Phys., F (London); 3: No. 2, 393-421(Feb 1973).

The progress made at Cornell University over the past few years in applying the field ion microscope (FIM) technique to the study of point defects in irradiated or quenched metals is reviewed. The techniques involve essentially the atom-by-atom dissection of specimens by pulse field evaporation and the corresponding recording on film of the extensive number of FIM images produced at each stage of the process. Methods were developed which allow the recording and the analysis of as many as approximately $5 \times 10^5$ frames of 35 mm cine film for a single investigation. The application of these techniques to the following problems were discussed: (i) the mobility of self-interstitial atoms (SIA) in substage $I_E$ of irradiated tungsten and platinum, (ii) the geometric configuration of the SIA, (iii) the point defect structure of depleted zones in tungsten, and (iv) the properties of monovacancies and divacancies in quenched platinum. (auth)

**23810** TRANSMISSION ELECTRON MICROSCOPE STUDIES OF POINT DEFECT CLUSTERS IN fcc AND bcc METALS. Eyre, B. L. (Atomic Energy Research Establishment, Harwell, Eng.). J. Phys., F (London); 3: No. 2, 422-470(Feb 1973).

The contribution that transmission electron microscopy has made to the understanding of the mobility and clustering of point defects in fcc and bcc metals is reviewed. The first part of the paper considers the nucleation and growth of vacancy clusters in quenched fcc metals. Most of the results have been obtained for gold and aluminum and a good understanding has been achieved of the factors governing the type of defects that are nucleated in these metals. In the second part of the paper the complex subject of irradiation damage is discussed with emphasis being placed on showing the inter-relationship existing between basic damage processes governing defect production and the visible defect structure. A self-consistent picture is now emerging of the damage structures produced by irradiation at low temperatures, which provides a basis for understanding the sometimes very varied results obtained in different experiments. The third section of the paper discusses the observation of cluster growth and shrinkage in terms of the information they provide about defect mobility. In the final part of the paper a summary is presented of the main conclusions that can be drawn from electron-microscope studies regarding the behavior of vacancy and interstitial defects in fcc and bcc metals. (auth)

**23811** RECOVERY OF IRRADIATED AND QUENCHED METALS. Schilling, W.; Sonnenberg, K. (Kernforschungsanlage, Juelich, Ger.). J. Phys., F (London); 3: No. 2, 322-350(Feb 1973).

The present state of understanding of the defect reactions occurring during the annealing of irradiated metals is reviewed. These reactions are presently understood best for recovery stage I. In this stage—aside from close pair recovery—freely migrating interstitials react with vacancies, other interstitials, and impurity traps. Both the annealing and damage rate studies (at temperatures above stage I) have established a consistent and quantitative picture for this stage. However, some metals, like Au, do not show a well-defined stage I. There is evidence that in these metals interstitials, even when introduced at the lowest temperatures, end up at traps or other interstitials or vacancies (giving rise to pronounced radiation annealing) so that no annealing stages are observed which can be associated clearly with free interstitial migration. Stage II annealing involves primarily the rearrangement of the interstitial clusters nucleated in stage I. Growth of larger clusters is obtained at the expense of smaller ones. In addition, in samples where extensive trapping of interstitials at impurities has occurred in stage I, detrapping of the interstitials from these impurities is observed in stage II. For a number of metals there is now clear evidence that single vacancies become mobile in stage III and annihilate at the interstitial clusters remaining from lower temperatures. For Al, Pt, and Au, a consistent and quantitative interpretation of stage III annealing can be made using the vacancy data obtained from equilibrium measurements at high temperatures. In metals (e.g. Cu) where incomplete annealing is observed, vacancy clustering takes place along with annihilation processes. For Cu the present equilibrium data predict that single vacancies would be practically immobile in stage III and this fact leaves the major question to be answered in the annealing of irradiated metals. It is concluded that even in view of this difficulty, a vacancy mechanism is more compatible with other evidence than a mechanism involving a second type of interstitial. (auth)

**23812** EFFECT OF NEUTRON IRRADIATION DOSE ON THE ANELASTIC BEHAVIOR OF Al DEFORMED AT 80K. Fantozzi, G.; Fouquet, F.; Gobin, P. F. (Institut National des Sciences Appliquees, Villeurbanne, France). Compt. Rend., Ser. B; 275: No. 25, 943-946(18 Dec 1972). (In French).

The anelastic behavior of 99.999% pure Al irradiated with neutrons and deformed at 80°K is sensibly different to that observed directly after cold working. This difference is due mainly to the presence of clusters of interstitials after irradiation and to the formation of clusters of vacancies during annealing. The effect of the irradiation dose on these properties was examined. (France)

**23813** EFFECT OF IMPURITIES ON ANNEALING OF RADIATION DEFECTS IN THIN SILVER FILMS. Chechetenko, V. V.; Tishchenko, L. P.; Peregon, T. I.; Fogel, Ya. M.; Kostin, E. G.; Vesnovatyi, Yu. A. Fiz. Khim. Obrab. Mater.; No. 6, 60-64(1972). (In Russian).

The effect of foreign atoms of He and oxygen were studied on the annealing of radiation defects produced in 500-Å thick films of Ag by 40-keV protons. The foreign atoms were implanted by bombarding the Ag films with ions of the particular gas. The implantation of He in the Ag equivalent to He : Ag = 1 : 1 had no effect on the annealing of radiation defects. The annealing rate was diminished, however, by oxygen implantation; this phenomenon was associated with the formation of Ag/O complexes. (tr-auth)

## Physical Properties

*Refer also to abstracts 22881 and 23480.*

**23814** (AD-750746) RESEARCH AND DEVELOPMENT OF RARE-EARTH—TRANSITION METAL ALLOYS AS PERMANENT-MAGNET MATERIALS. Semiannual Interim Technical Report, 1 January—30 June 1972. Ray, A. E.; Strnat, K. J. (Dayton Univ., Ohio. Research Inst.). Aug 1972. Contract F33615-70-C-1625. 81p. (UDRI-TR-72-41; AFML-TR-72-202). NTIS.

The results of thermomagnetic analyses of the $R_2(Co_{1-x}Fe_x)_{17}$ phases with R = Ce, Pr, Sm, Y, and MM above room temperature are reported, as well as the results of room temperature saturation magnetization for the phases with R = Ce, Pr, Nd, Sm, and Y. The magnitude of the magnetocrystalline anisotropy was measured on a large number of magnetically aligned powder specimens for the ternary phases with R = Ce, Pr, Sm, Y, and MM. The phase $Ce_2(Co_{0.5}Fe_{0.5})_{17}$ was re-examined by metallographic, x-ray diffraction, and electron microprobe analyses to explain the unusual thermal and magnetic transitions observed by DTA and TMA for the iron-rich $Ce_2(Co_{1-x}Fe_x)_{17}$ phases with $0.4 \leq x \leq 0.7$. The neodymium—cobalt alloy system was re-examined and a revised phase diagram is proposed. The results of some preliminary sintering experiments using $NdCo_5$ and $DiCo_5$ as base metals and 60 Sm/40 Co and 70 Pr/30 Co alloys as sintering aids are reported. (auth)

**23815** (IS-T-568) OPTICAL PROPERTIES OF SOME TRANSITION METALS. Weaver, J. H. (Ames Lab., Iowa). Feb 1973. Contract W-7405-eng-82. 81p. Dep. NTIS $6.25. Thesis.

The absorptivity of the bcc transition metals V, Nb, Ta, and Mo and hcp Y was measured calorimetrically at near-normal incidence in the energy range 0.1 to 4.88 eV. Unpolarized radiation was used for the bcc metals; for Y the radiation was polarized to obtain the spectra with $\vec{E} \parallel \hat{c}$ and $\vec{E} \perp \hat{c}$. For the bcc metals, the low-energy region was shown to be free of structure. Interband absorption was found to be large even at 0.15 eV and was thought to persist to zero energy, although it did not contribute structure below the first strong absorption peak. For Y, low-energy interband structure was observed only for $\vec{E} \parallel \hat{c}$ at about 0.45 eV. The peak of the first strong absorption occurs at 1.35 eV (V), about 1.8 eV (Nb), 2.15 eV (Ta), and 1.5 eV (Mo). For the Vanadium series, this was identified as due to transitions like $\Sigma_1-\Sigma_1$; for Mo, the structure is probably due to transitions along $\Delta$. Structure which occurs in Nb and Ta at 5.1 and 5.3 eV, respectively, is discussed in terms of the flat band extending along P(D)N. It is suspected that V will also possess such a feature, but it occurs outside the range of the data presented. Comparisons are made with existing optical data on these metals and the band structures are discussed where possible. For V, the shortcomings of the existing bands are pointed out, based on the optical data. The Y results are interpreted based on the bands of Sc. (auth)

**23816** (LBL-1424) TRANSITION METAL ALLOYS: A CHEMIST'S VIEW. Brewer, L. (California Univ., Berkeley. Lawrence Berkeley Lab.). Nov 1972. Contract W-7405-eng-48. 16p. (CONF-721114-19). Dep. NTIS.

From 18th annual conference on magnetism and magnetic materials; Denver, Colorado, USA (28 Nov 1972).

The valence-bond model, so widely used in chemistry, is equally applicable to transition-metal alloys. In contrast to models commonly used by physicists, this model emphasizes the distribution of electrons in real space and the differences in spatial distribution of f and d electrons in contrast to s and p electrons. From the energies of the different electronic configurations that are known for almost all of the gaseous atoms and bonding energies for different types of electrons, one can calculate the energies of the electronic configurations in the metal. Thus Ba, Ta, and W with gaseous ground states $s^2$, $d^3s^2$, and $d^4s^2$ are calculated to have the predominant configurations ds, $d^4s$, and $d^5s$, respectively, in the metal. The determination of the correct electronic configuration in the metal is the keystone to reliable predictions. The bonding energies due to the different types of electrons can be used to readily evaluate thermodynamic data to predict the stable composition range for a given structure, of the crystal structure that is stable at a given composition and temperature, and the effect of pressure, temperature, and alloying upon the relative stabilities of different structures as well as the occurrence of magnetism. (19 references) (auth)

**23817** INFLUENCE OF THE ELECTRON—PHONON SCATTERING ON THE TOTAL ENERGY DISTRIBUTION OF FIELD-

EMITTED ELECTRONS FROM TUNGSTEN. Czyzewski, J. J. (Univ., Wroclaw). Surface Sci.; 33: No. 3, 589-606(Dec 1972).

The total energy distribution (TED) of field-emitted electrons was measured for [012] direction of tungsten monocrystal in temperature region from 78 to 950°K. To compare measurements with the free-electron (FE) theory, the parameters of FE equation of TED were calculated by extrapolation of experimental results to the zero temperature. The explanation of results is proposed, taking into account the electron scattering phenomena of electrons supplied to the surface during the emission. Characteristic features of s → d and s → s scattering in transition metals described by Mott's theory are indicated by TED curves for the [012] direction. The Nottingham effect measured for [012] is discussed as well. (auth)

**23818** NMR AND MAGNETIC SUSCEPTIBILITY OF THE INTERMETALLIC PSEUDO-BINARY COMPOUNDS: $Ce_{1-x}R_xAl_3$ WITH R = Y AND La. Niculescu, V. (Univ., Cluj); Pop, I.; Rosenburg, M. Acta Phys. Pol., A; A43: No. 2, 279-286(Feb 1973).

The NMR and magnetic susceptibility of the intermetallic pseudo-binary compounds $Ce_{1-x}Y_xAl_3$ (x = 0.1; 0.05; 0.1) and $Ce_{0.9}La_{0.1}Al_3$ were investigated. As a result of the magnetic dilution of the rare-earth sublattice, the indirect exchange interaction between the Ce ions via the conduction electrons polarization is weakened and the negative paramagnetic Curie temperature decreases with the increase in the Y concentration. The higher values of the temperature-independent term in the magnetic susceptibility of $Ce_{1-x}Y\ Al_3$ compounds as compared with $CeAl_3$ is due to the increase in the orbital susceptibility of the d electrons as a result of the $4d^25s^1$ outer electron configuration of the metallic Y. The presence of a second peak with a lower Knight shift in the $^{27}Al$ NMR spectrum is the evidence that besides the Al sites surrounded in the first coordination sphere as in $CeAl_3$ there are also Al nuclei positioned in the vicinity of an Y or La ion. (auth)

**23819** BREAKDOWN OF THE ELECTROMAGNETIC SCREENING OF TRANSVERSE ULTRASONIC PHONONS IN CADMIUM. Almond, D. P.; Lea, M. J.; Dobbs, E. R. (Univ. of Lancaster, Eng.). Phys. Lett.; 43A: No. 1, 69-70(12 Feb 1973).

Measurements of the absorption of fast shear waves in cadmium along $[11\bar{2}0]$ in the frequency range 10 to 760 MHz showed that the electromagnetic screening begins to break down at 200 MHz. (auth)

**23820** COULOMB INTERACTIONS IN METALLIC $VO_2$. Hearn, C. J.; Hyland, G. J. (Univ. of Warwick, Coventry, Eng.). Phys. Lett.; 43A: No. 1, 87-88(12 Feb 1973).

The intra-cationic Coulomb energy in the metallic phase of $VO_2$ is estimated using a model in which the observed spin susceptibility and its temperature dependence arise from correlation-modified exchange enhancement of the spin susceptibility of the d subbands. (auth)

**23821** PARAMAGNETIC SUSCEPTIBILITY ANISOTROPY OF $Nd_2O_3$ AND $La_xNd_{2-x}O_3$ SINGLE CRYSTALS. Bernier, J. C.; Lejus, A. M.; Tueta, R.; Collongues, R. (Paris Univ., Orsay France). Mater. Res. Bull.; 8: No. 3, 261-270(Mar 1973). (In French).

Single crystals of neodymium oxide $Nd_2O_3$ and of a solid solution $La_{0.4}Nd_{1.6}O_3$, both with hexagonal A structure, were obtained by Verneuil Process adapted to plasma torch. Paramagnetic-susceptibilities measurements were performed on these crystals at constant temperatures (5, 77, and 300° K) with various orientations of the magnetic field with regard to crystallographic axes. The curves are of the type $\chi = A + B \cos 2\Theta$. Variations of susceptibility versus temperature in the range 5 to 300°K clearly show an anistropy. The perpendicular susceptibility varies roughly according to a Curie–Weiss law, whereas the variation of parallel susceptibility may be explained by an evolution of $Nd^{3+}$ magnetic moment due to crystal field at low temperatures. (auth)

**23822** EFFECT OF HIGH HYDROSTATIC PRESSURES ON THE ATOMIC STRUCTURE OF A TUNGSTEN SURFACE. Dmitriev, V. N.; Potapov, L. P.; Shiryaev, P. P. (Inst. of Metal Science and Physics of Metals, Moscow). Dokl. Akad. Nauk SSSR; 206: No. 5, 1093-1095(11 Oct 1972). (In Russian).

Samples of tungsten that had been annealed for 5 min at 1500°C were subjected to pressures of from 10 to 20 kbars (20 s, 1 h, 2 h) at a loading rate of 2 to 3 kbars/min, using benzene or kerosene at the pressure-transmitting medium. The samples were subsequently studied with an ion microscope for defects and atomic structural changes. The high density of dislocations observed were associated with the high pressures exerted on the samples; the effect of high pressures on the structure of the W surface was dependent on the magnitude and duration of the pressure. (KSW)

**23823** MAGNETIC PROPERTIES OF RARE EARTH–LEAD ALLOYS. Lethuillier, P. (Centre National de la Recherche Scientifique, Grenoble, France); Quezel-Ambrunaz, G.; Percheron, A. Solid State Commun.; 12: No. 2, 105-108(15 Jan 1973). (In French).

The low-field susceptibility of $TPb_3$ compounds (T = Pr, Nd, Sm, Tb, Dy, Ho) was studied between 3 and 300°K. All these compounds except $SmPb_3$ follow a Curie–Weiss law with a paramagnetic moment close to the free ion value. The compounds with Sm, Tb, Dy and Ho order antiferromagnetically. The magnetization of the three last compounds was studied in static magnetic fields up to 85 kOe. (auth)

**23824** NEUTRON CRYSTAL-FIELD SPECTROSCOPY AND SUSCEPTIBILITY IN $Tm_xY_{1-x}Al_2$. Purwins, H. G. (Univ., Geneva); Walker, E.; Donze, P.; (and others). Solid State Commun.; 12: No. 2, 117-119(15 Jan 1973).

Inelastic neutron scattering due to crystalline electric field transitions is observed in $Tm_{0.25}Y_{0.75}Al_2$. The best fit of the theoretical cross section to experiment is obtained for the Lea, Leask and Wolf (J. Phys. Chem. Solids; 23: 1381 (1962)) parameters for the rare earth ion in cubic symmetry W = (0.040 ± 0.005) meV and X = (0.50 ± 0.05). The extrapolation of the measured susceptibility of $Tm_xY_{1-x}Al_2$ (x = 0.05, 0.15, 0.25) to x = 0 is in good agreement with theory when using the above parameters. (auth)

**23825** LOW-TEMPERATURE HEAT CAPACITIES AND RELATED THERMODYNAMIC FUNCTIONS OF PRASEODYMIUM DIHYDRIDE $PrH_2$. Crystal Field Effects. Bieganski, Z. (Instytut Niskich Temperatur i Badan Strukturalnych, Wroclaw). J. Chem. Thermodyn.; 5: No. 1, 1-7(Jan 1973).

The heat capacity of praseodymium dihydride $PrH_{2.00}$ was measured over the temperature range 23 to 342°K by adiabatic calorimetry. At T = 298.15°K, the measured heat capacity at constant pressure $C_p$, the entropy $S^0$, the enthalpy $\{H^0(T) - H^0(0)\}$ and the function $-\{G^0(T) - H^0(0)\}/T$ are: 9.83 $cal_{th}\ K^{-1}\ mol^{-1}$, 13.57 $cal_{th}\ K^{-1}\ mol^{-1}$, 1832 $cal_{th}\ mol^{-1}$, and 7.42 $cal_{th}\ K^{-1}\ mol^{-1}$ respectively. The influence of a crystal field of cubic symmetry on the splitting of the ground state $^3H_4$ of the praseodymium ion $Pr^{3+}$ was analyzed, and the conclusion was drawn that the triplet $\Gamma_5$ is the lowest lying level which supports the anionic-like character (hydridic model) of hydrogen in this hydride. (auth)

**23826** HEAT CAPACITY AND DERIVED THERMODYNAMIC FUNCTIONS OF $NpC_{0.91}$ FROM 15 TO 373 K. Sandenaw, T. A.; Gibney, R. B.; Holley, C. E. (Los Alamos Scientific Lab., NM). J. Chem. Thermodyn.; 5: No. 1, 41-47(Jan 1973).

Heat capacities of $NpC_{0.91}$ were determined between 15 and 373°K and values of derived thermodynamic functions were calculated. This composition of neptunium carbide reported to be ferromagnetic below (225 ± 5)°K and antiferromagnetic below 280°K. The heat capacity shows a λ-type anomaly that peaks at (228.4 ± 0.2)°K and the anomaly is attributed to ferromagnetic ordering. In the temperature range 240 to 310°K, the heat capacities were not reproducible. Values of $C_p(T)$, $S^0(T)$, and $-\{G^0(T) - H^0(0)\}/T$ were determined to be 11.96, 11.65, and 7.82 $cal_{th}\ K^{-1}\ mol^{-1}$ and $\{H^0(T) - H^0(0)\}$ to be (2634 ± 35) $cal_{th}\ mol^{-1}$, at T = 298.15°K. (auth)

**23827** DETERMINATION OF FERMI SURFACE AND SCATTERING PROPERTIES OF NIOBIUM FROM MAGNETORESISTANCE MEASUREMENTS. II. COMPARISON WITH MEASUREMENTS. Lehmann, G. (Institutsteil fuer Metallphysik und Reinstmetalle, Dresden); Kutscherenko, J. N. Monatsber. Deut. Akad. Wiss. Berlin; 13: No. 10-12, 880-893(1971). (In German).

Previous statements about parameters of the Fermi surface, which appeared independent of any particular model, are compared with experimentally determined magnetoresistance curves for niobium. The measurements allow determinations of the diameter of the necks in the Fermi surface at the narrowest spots, location of these spots, the curvature at these spots, and of a parameter for the overlapping of nodes. (tr-auth)

**23828** DETERMINATION OF FERMI SURFACE AND SCATTERING PROPERTIES OF NIOBIUM FROM MAGNETORESISTANCE MEASUREMENTS. I. Model Studies. Lehmann, G. (Institutsteil fuer Metallphysik und Reinstmetalle, Dresden); Kutscherenko, J. N. Monatsber. Deut. Akad. Wiss. Berlin; 13: No. 10-12, 857-880(1971). (In German).

In the presence of open trajectories, statements can be made about the topology of the Fermi surface from measurements of the magnetoresistance. The present study examines the degree to which magnetoresistance can be used for measurements of both parameters of the Fermi surface and scattering behavior of defects. Based on Mattheiss' band computations for niobium, the thickness of the layer with open trajectories, which is directly connected to the magnetoresistance, is calculated for various models and the results are compared with experimental data. The measurements permit statements about the diameter of the necks in the Fermi surface at the narrowest spots, location of these spots, and about a parameter for the overlapping of nodes. (tr-auth)

**23829** PHYSICAL PROPERTIES OF THE NEODYMIUM–YTTRIUM ALLOY SYSTEM. Vereshchaka, N. P.; Kobzenko, G. F.; Bryukhanov, A. E.; Nemchenko, V. F. (Kherson State Pedagogical Inst., USSR). Metallofizika; No. 42, 76-85(1972). (In Russian).

The heat and electrical conductivity, magnetic susceptibility, Hall coefficient, thermal emf, and thermal expansion were investigated for Nd–Y alloys in the temperature range 100 to 800°K. The concentration dependence of the ratio of the specific electrical resistance at 293°K to the corresponding value at 77°K was determined. An $\alpha_{Nd-y}$ phase which contained 30 to 90% Y was observed to separate from the alloy. This $\alpha_{Nd-y}$ phase possessed an altered electronic structure which was reflected in a change in the magnetic moments of the atoms. Inversions in the signs of the Hall coefficient and the thermal emf during changes in the concentration of the components bore witness to the hybrid mechanism of the electrical conductivity. (tr-auth)

**23830** THERMAL CAPACITY OF A TANTALUM ALLOY WITH TUNGSTEN (TV-10) AT LOW TEMPERATURES. Krylovskii, V. S.; Ovcharenko, V. I.; Pervakov, V. A.; Khotkevich, V. I. (Kharkov State Univ.). Metallofizika; No. 42, 85-86(1972). (In Russian).

The specific heat ($C_p$) of 99.8% Ta and its solid solutions with TV-10 tungsten was determined over the temperature interval 10 to 300°K, obtaining good agreement with previously published values. The $C_p$ of the alloy was consistently lower than the $C_p$ of Ta. The effects were interpreted in terms of a strengthening of interatomic bonds caused by an increase in the electron density during dissolution of W. (tr-auth)

**23831** PINNING OF DISLOCATIONS BY IMPURITIES INTRODUCED IN METALS WITH BCC LATTICES. Golub, T. V.; Benieva, T. Ya.; Polotskii, I. G. (Inst. of Metal Physics, Kiev). Metallofizika; No. 42, 106-112(1972). (In Russian).

The inner friction in the function of amplitude deformation was studied in single crystals of Mo and W with additions of 0.1% Re by a resonance method. The measurement of internal friction was performed after preliminary heat treatment at 0.7 $T_f$ for 2 h with cooling at the rate of 11°/min and subsequent heating in the interval 150 to 900°C with rapid cooling. (tr-auth)

**23832** TEMPERATURE DEPENDENCE OF HELICON DAMPING IN INDIUM. Vol'skii, E. P.; Petrashov, V. T. (Inst. of Solid State Physics, Moscow). Zh. Eksp. Teor. Fiz.; 64: No. 1, 254-260(Jan 1973). (In Russian).

It is found experimentally that damping of helicons may be a monotonous as well as nonmonotonous function of temperature. The nonmonotonous dependence may be explained by Landau damping becoming involved with increase of the electron mean free path l on decrease of temperature. Collision and Landau damping are separated experimentally and studied. Collision damping varies with temperature as $T^4$. The dependence of Landau damping on l in In qualitatively differs from that in an isotropic metal. (auth)

**23833** STUDIES ON DIFFUSION OF BORON THROUGH SILICON OXIDE FILMS. Mukherjee, S. P.; Evans, P. E. (Univ. of Manchester, Eng.). Thin Solid Films; 14: No. 2, 299-303(15 Dec 1972).

The diffusion of boron through silica films deposited on n-type silicon in a rf glow discharge was investigated. The results show that the diffusion coefficient of boron at 1150°C obtained with the rf discharge films is one to two orders of magnitude higher than that obtained with thermally grown oxide and an order of magnitude higher than that obtained with sputtered oxides. The diffusion coefficient can be expressed as $D = 2.39 \times 10^{-5} \exp(-59{,}000/RT)$ $cm^2$/sec in the temperature range 1100 to 1200°C. (auth)

**23834** TEMPERATURE COEFFICIENT OF RESISTANCE OF BETA TANTALUM FILMS AND MIXTURES WITH BCC TANTALUM. Schwartz, N.; Reed, W. A.; Polash, P.; Read, M. H. (Bell Telephone Labs., Murray Hill, NJ). Thin Solid Films; 14: No. 2, 333-347(15 Dec 1972).

Beta-tantalum films obtained from various bell jar systems were studied for their resistivity characteristics down to 4.2°K. Films which had no detectable bcc-tantalum had linear $\alpha$ values of $-150 \pm 30$ ppM/°C over the temperature range of 4.2 to 380°K. Films with increasing amounts of bcc-tantalum tended to have an increasing positive $\alpha$ value in the temperature range of 4.2 to 100°K, and with sufficient bcc-tantalum, a maximum in resistivity can occur. The pure beta-tantalum films with the negative constant $\alpha$ values had superconducting transitions of 0.96–0.67°K. Mixed beta- and bcc-tantalum films were prepared by nitrogen doping, and these films confirm that the presence of bcc material causes an increasing positive $\alpha$ value at low temperatures. The conversion temperature of beta- to bcc-tantalum, determined on stripped film material, was confirmed to have a high value of 800 to 850°C. Despite this high value, the shape of the low-temperature resistivity curve indicates that mixtures of bcc- and beta-tantalum can be deposited by sputtering at substrate surface temperatures of 400 to 465°C. The $\alpha$ values between 4.2 and 77°K or between 77 and 196°K are particularly sensitive to the amount of bcc-material in the film. The $\alpha$-value method of analysis to detect bcc-material is probably more sensitive than the x-ray method. (auth)

**23835** STRUCTURAL AND ELECTRICAL PROPERTIES OF SPUTTERED TUNGSTEN FILMS. Sheng, T. T.; Marcus, R. B.; Alexander, F.; Reed, W. A. (Bell Telephone Labs., Murray Hill, NJ). Thin Solid Films; 14: No. 2, 289-298(15 Dec 1972).

The room-temperature resistivity of rf diode sputtered tungsten films has been found to undergo a significant decrease after 900°C anneal. This paper reports on a measurement of the resistivity of these films over the range 4 to 298°K before and after anneal, and a study of the relationship between resistivity and film morphology as revealed by electron microscopy. A resistivity decrease of ~8 $\mu\Omega$ cm and 22 to 40 $\mu\Omega$ cm was measured after 1 hour $H_2$ anneal at 900 and 1000°C, respectively. A value of 0.030 $\mu\Omega$ cm $deg^{-1}$ was found for $d\rho/dT$ for all films before and after anneal, and Matthiessen's rule was found to be obeyed. A smoother grain surface texture develops on the film surface, and the grain size (~1000 Å) remains nearly unchanged following anneal. The resistivity decrease is considered to be due primarily to a drastic reduction in the defect structure of the tungsten and to an associated loss or redistribution of interstitials and vacancies. (auth)

**23836** INFLUENCE OF A MAGNETIC FIELD ON THE CRYSTAL STRUCTURE OF DYSPROSIUM. III. Finkel, V. A.; Belovol, V. S. (Physical-Technical Inst., Kharkov). Zh. Eksp. Teor. Fiz.; 64: No. 1, 173-180(Jan 1973). (In Russian).

An x-ray study is made of magnetostriction of dysprosium in the ferro-, antiferro- and paramagnetic states at 77 to 293°K in magnetic fields up to 16 kOe. It is shown that variation of the crystal lattice size in a magnetic field when $T_c < T < T_n$ due to changes in the orientation of the magnetic moments in the basic plane of the hexagonal close-packed lattice is much greater than the effects due to magnetostriction of the paraprocess at $T < T_c$ and $T > T_n$. Magnetostriction deformations of the lattice in the antiferromagnetic state increase with increase of temperature. (auth)

## Moessbauer Effects and NMR

**23837** $^{155}Gd$ AND $^{157}Gd$ NMR IN FERROMAGNETIC GADOLINIUM METAL. Seiwa, Y. (Kyoto Univ.); Tsuda, T.; Hirai, A.; Searle, C. W. Phys. Lett., A; 43A: No. 1, 23-24(12 Feb 1973).

Isotropic hyperfine field and the quadrupole coupling constant at $^{157}Gd$ nuclei in ferromagnetic gadolinium metal were found to be $-(374 \pm 9)$ kOe (or 64.2 ± 1.5 MHz) and (+) 81.6 ± 4.0 MHz, respectively. (auth)

**23838** CRYSTALLINE FIELDS AND EXCHANGE INTERACTIONS IN $YbNi_2$.. Nowik, I.; Dunlap, B. D. (Argonne National Lab., IL). J. Phys. Chem. Solids; 34: No. 3, 465-471(Mar 1973).

Moessbauer studies of $^{170}Yb$ in $YbNi_2$ at temperatures of 1.4 to 15°K and in external fields up to 44 kOe reveal that $YbNi_2$ is magnetically ordered below 5.7 ± 0.4°K. Analysis of the experimental results within molecular-field and crystal-field theory approximations yield the cubic crystalline field constants $A_4\langle r^4\rangle = 44 \pm 2$ $cm^{-1}$, $|A_6\langle r^6\rangle| < 2$ $cm^{-1}$, and the Yb–Yb first nearest neighbor exchange constant J = 16°K. These results are compared with a previous calculation of Bleaney and with crystal field constants in the rare-earth–$Al_2$ systems. Effects of crystal field mixing on details of the hyperfine spectra and on the systematics of the Curie temperature for the rare-earth–$Ni_2$ compounds are considered. (auth)

**23839** MOESSBAUER EFFECT DATA INDEX. Covering the 1971 Literature. Stevens, J. G.; Stevens, V. E. (eds.). New York; Plenum Publishing Corporation (1972). 437p. $32.50.

This volume in the annual series includes 940 entries, with over 1100 references and information on more than 2900 absorber–source combinations. Two papers on calibration methods, and nomenclature and conventions for reporting data are included. Besides the instructions, equipment, tables, graphs, and the index and lists, an addendum reference list (1969 and 1970) and a 1972 partial reference list are also included. (DLC)

# PHYSICS (THEORETICAL)

*Refer also to abstracts 23414, 23425, 23446, and 23619.*

**23840** SUPERLUMINAL INERTIAL FRAMES. Ramanujam, G. A.; Namasivayam, N. (Nallamuthu Gounder Mahalingam Coll., Pollachi, India). Lett. Nuovo Cim.; 6: No. 7, 245-249(17 Feb 1973).

Lorentz transformations, in four dimensions, between two frames with a superphotic relative velocity between them and their consequences have recently been given. Results of independent investigations along these lines are obtained, not by assuming a priori the validity of Einstein's law of addition of velocities for superluminal particles, as was done in the previous work, but by a simple interpretation of the second axiom of special relativity. (LBS)

**23841** STRUCTURAL PROPERTIES AND FINITE-RANGE POLYNOMIAL SOLUTIONS OF THE LINEAR BOLTZMANN EQUATION. Syros, C. (Euratom, Brussels). Lett. Nuovo Cim.; 6: 273-274(17 Feb 1973).

The construction of polynomial solutions of the homogeneous and inhomogeneous Boltzmann equation is presented. (LBS)

**23842** EIGENFUNCTIONALS OF THE ONE-DIMENSIONAL TRANSPORT OPERATOR IN MODEL APPROXIMATIONS. Silvennoinen, P. (Univ. of Helsinki). Acta Polytech. Scand., Phys. Nucl. Ser.; No. 87, 1-18(1972).

Eigendistributions of the linear Boltzmann operator are constructed in modal approximations. The formalism is a generalization of the conventional multigroup theory. Eigendistributions consist of the principal value functionals and the derivatives of the $\delta$-distribution. The customary proof of completeness of the normal modes is not applicable here. In a simple case of symmetric scattering an auxiliary set of functionals is shown to be complete when augmented with the ordinary discrete eigenfunctions. (auth)

**23843** PROCEEDINGS OF THE SIXTH BERKELEY SYMPOSIUM ON MATHEMATICAL STATISTICS AND PROBABILITY. Volume III. Probability Theory. Conference held at Berkeley, California, June 21–July 18, 1970. Le Cam, L. M.; Neyman, J.; Scott, E. L. (eds.). Berkeley and Los Angeles, CA; University of California Press (1972). 729p. (CONF–700668–(Vol. 3)). $22.50.

From 6th symposium on mathematical statistics and probability; Berkeley, California, USA (21 Jun 1970).

The topics covered by the conference include passage problems, Markov processes in potential theory, trajectories and functions for Markov processes, point and branching processes, and information and control. (JFP)

**23844** IMPROPER PROBLEMS IN COMPUTATIONAL PHYSICS. Nedelkov, I. P. (Inst. of Physics, Sofia). Comput. Phys. Commun.; 4: No. 2, 157-164(Nov 1972).

Several examples of improper problems in computational physics are considered. The examples are from astrophysics, atomic physics, biophysics, geophysics, high-energy physics, hydrodynamics, nuclear physics, plasma physics, solid state physics and statistical mechanics. The basic methods for solving improper problems—the method of regularization and the method of selection—are briefly discussed. (auth)

**23845** REMARKS ON THE COMPUTATION OF COULOMB WAVEFUNCTIONS. Koelbig, K. S. (CERN, Geneva). Comput. Phys. Commun.; 4: No. 2, 214-220(Nov 1972).

. Recent work on the computation of Coulomb wavefunctions is reviewed, and references are given. (auth)

**23846** PARASTATISTICS AND DIRAC BRACKETS. Kalnay, A. J. (Instituto Venezolano de Investigaciones Cientificas, Caracas). Int. J. Theor. Phys.; 6: No. 6, 415-424(Dec 1972).

Parastatistics (parafields) has been used in relation to several models of physical systems like the quark and the nuclear shell models. However, the physics of parafields is not completely clear. If classical para-Bose or para-Fermi variables could be constructed, then because of the correspondence principle some traces of the corresponding quantum properties could be found at the classical limit. In this way, by studying the simplest c-number systems some hints for the quantum of parafields could be expected. Classical paravariables are introduced and discussed. c-number para-Fermi variables are constructed in terms of coupled classical oscillators. Several similarities to the corresponding quantum case are observed. The results support Cusson's remark that systems described in terms of parastatistics may really be composite systems. (auth)

**23847** RELATION BETWEEN CLASSICAL AND QUANTUM MECHANICS. Grgin, E.; Petersen, A. (Yeshiva Univ., New York). Int. J. Theor. Phys.; 6: No. 5, 325-337(Dec 1972).

Expressions for the Lie derivatives of functions of non-commuting variables are derived and used to reformulate classical mechanics. This is possible only if the phase space variables commute, or if they satisfy Heisenberg's commutation relations. (auth)

**23848** GROUND STATE ENERGY OF A MANY-PARTICLE BOSON SYSTEM. Grypeos, M. E. (Univ. of Thessaloniki, Greece). Int. J. Theor. Phys.; 6: No. 6, 425-435(Dec 1972).

A trial expression for the ground state energy of a system of many bosons interacting with strong forces is studied. Using an approximate expression for the pair-distribution function and applying the variational principle in an appropriate way, a nonlinear integro-differential equation is obtained for the correlation function f(r). This equation is subsequently linearized and its behavior for large separations is studied. It is also shown that for large separations an effective reduced mass of the pair can be defined. This is given by $\mu^* = 2\mu$, where $\mu = m/2$ is the reduced mass of the pair. (auth)

**23849** EVALUATION OF A CLASS OF INTEGRALS BY SUMMING LEGENDRE SERIES. 2. Integrands Containing Spherical Harmonics. Coleman, J. P. (Univ. of Durham, Eng.). J. Phys., B (London); 5: No. 12, 2155-2167(Dec 1972).

It is shown how the integral $\int f(r)Y_{LM}(\theta,\phi)|r-R|^{-1}|r-R|^{-1}\,dr$ can be reduced to a single integral on the interval [0,1] which is amenable to numerical computation. The analysis does not depend on the functional form of f(r). Integrals involving products of spherical harmonics are also discussed, in particular the case where the integrand contains a product of two spherical harmonics. (auth)

**23850** EXACT SOLVABILITY OF THE TIME-DEPENDENT SCHROEDINGER EQUATION. Balasubramanian, S. (Madurai Univ., India). Indian J. Pure Appl. Phys.; 10: No. 6, 409-411 (Jun 1972).

The question of exact solvability of the time-dependent Schroedinger equation is discussed by considering the possibility of constructing a suitable transformation which would "kill" the time-dependence of the Hamiltonian. The case when the Hamiltonian is a linear combination of Lie elements is considered and an analytical criterion is obtained for finding a suitable unitary transformation. The special case of the linear combination of angular momentum operators is discussed with reference to the well known spin problem in magnetic resonance. (auth)

**23851** IDENTITY OF COMMUTATOR AND POISSON BRACKET. Bloore, F. J. (Univ. of Liverpool). J. Phys., A (London); 6: No. 2, L7-L8(Feb 1973).

The commutator of two functions of n noncommuting variables is proved to be identical to their Frechet–Poisson bracket. (auth)

**23852** QUASIEQUIVALENCE OF QUASI-FREE STATES ON THE C* ALGEBRA ANTICOMMUTATION RELATIONS. Kholevo, A. S. (Mathematics Inst., Moscow). Teor. Mat. Fiz.; 14: No. 2, 145-151(Feb 1973). (In Russian).

Without assuming the gauge invariance, the necessary and sufficient conditions of quasiequivalence of the primary quasi-free states are obtained. (auth)

**23853** SYMMETRY PRINCIPLE IN QUANTUM MECHANICS. Yukalov, V. I. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; 13: No. 5, 566-572(1972). (In Russian).

A system of identical particles was considered, and conditions were investigated for which application of the symmetry principle for such a system was not compulsory. It was shown, for example, that a crystal could be described with good approximation of unsymmetrical, factorized product, wave functions. (tr-auth)

# REACTOR TECHNOLOGY

## Power Reactor Development

*Refer also to abstracts 24168, 24199, and 24204.*

**23854** (CONF-720466-(Pt.2)) INTERNATIONAL WORKING GROUP ON FAST REACTORS FIFTH ANNUAL MEETING, VIENNA, AUSTRIA, 19-21 April 1972. Summary Report. (International Atomic Energy Agency, Vienna (Austria)). [nd]. 226p. (In several languages).

A total of eleven papers was presented. Separate abstracts were prepared for six of these. One of the remaining papers is listed by title in NSA. (JWR)

*For abstracts of individual papers see: 23855–23861.*

**23855** (CONF-720466-(Pt.2), pp 7-29) PRESENT STATE OF DEVELOPMENT OF THE FAST BREEDER PROJECT IN THE FEDERAL REPUBLIC OF GERMANY AND IN THE BENELUX COUNTRIES AND PROGRESS ACHIEVED DURING 1971 AND EARLY 1972. Engelmann, P. (Gesellschaft fuer Kernforschung m.b.H., Karlsruhe, Ger.); Daeunert, U. [nd].

The activities of the fast breeder development group in the Federal Republic of Germany and the BENELUX countries since the last meeting of the International Working Group on Fast Reactors are summarized. (JWR)

**23856** (CONF-720466-(Pt.2), pp 35-57) REVIEW OF FAST REACTOR PROGRESS IN THE UK. Smith, R. D. (United Kingdom Atomic Energy Authority, Risley, Eng.). [nd].

The status of fast reactor development in the United Kingdom as of April 1972 is summarized. Research projects described include the prototype fast reactor, the commercial fast reactor, the Dounreay Fast Reactor, fuel and cladding studies, engineering development, physics, experimental physics, and safety research. (JWR)

**23857** (CONF-720466-(Pt.2), pp 59-69) STATUS OF FAST REACTOR RESEARCH AND DEVELOPMENT IN THE USSR. Krasnoyarov, N. Apr 1972. (In Russian).

**23858** (CONF-720466-(Pt.2), pp 71-132) STATUS OF THE U. S. A. LIQUID METAL FAST BREEDER REACTOR PROGRAM. Wensch, G. W. Apr 1972.

Highlights of the LMFBR development program are presented. (JWR)

**23859** (CONF-720466-(Pt.2), pp 133-156) DEVELOPMENT OF FAST REACTORS IN FRANCE FROM APRIL 1971-APRIL 1972. Vautrey, L. [nd]. (In French).

A brief summary of the development of fast sodium cooled reactors in France is presented. (JWR)

**23860** (CONF-720466-(Pt.2), pp 157-173) REVIEW OF FAST REACTOR PROGRESS IN JAPAN. Uchida, I.; Tomabechi, K. Apr 1972.

Fast reactor development in Japan is summarized. Research connected with JOYO and MONJU is briefly described. (JWR)

**23861** (CONF-720466-(Pt.2), pp 175-219) REVIEW OF FAST REACTOR PROGRESS IN ITALY. Pierantoni, F. Apr 1972.

Fast reactor development in Italy is reviewed. Most of the work is focused on the PEC reactor. (JWR)

**23862** (CONF-721104-9) MSBR AS A BACK-UP TO THE LMFBR FOR UTILIZATION OF THE WORLD'S NUCLEAR FUEL RESOURCES. Paper Number 18. Reichle, L. F. C. (Ebasco Services, Inc., New York). [nd]. 20p.

From INCO Power Conference; Kyoto, Japan (28 Nov 1972).

Breeder reactors are discussed from the standpoint of the utilization of nuclear fuel resources. The inherent and unique advantages of the molten salt breeder reactor are described. The members and the program of the Molten Salt Group are briefly sketched. (JWR)

**23863** (NP-19649) SUMMARY OF ACTIVITIES: JULY 1971-JULY 1972. (Reactor Centrum Nederland, The Hague). 1972. 20p. Dep. NTIS (U. S. Sales Only).

Activities at Reactor Centrum Nederland during July 1971 to July 1972 included research on water-cooled, helium-cooled, and sodium-cooled power reactors, fuel cycle studies involving the development of centrifuges and enrichment plants, and the use of the HFR at Petten for producing radioisotopes, activation analysis, and physics research. The financing and staffing of the Centrum and scientific papers published during the year are listed. (LCL)

**23864** (WCAP-7909) MARVEL: A DIGITAL COMPUTER CODE FOR TRANSIENT ANALYSIS OF A MULTILOOP PWR SYSTEM. Hargrove, H. G. (Westinghouse Electric Corp., Pittsburgh, Pa. Nuclear Energy Systems Div.). Oct 1972. 70p.

The MARVEL (Multi-Loop Analysis of Pressurized Water Reactor System Transient) digital computer code was developed to calculate multi-loop detailed transient behavior of pressurized water reactor systems. The program simulates two reactor coolant loops including two steam generators and the associated system. It also simulates the reactor kinetics, the reactor control and protection system, safeguards system and other subsystems. The code can also be used for three or four loop plants by assuming that the other loops are operated in the same way as either of the two loops. The reactor systems in the program conform to systems designed for current Westinghouse PWR's, e.g., the Wisconsin Power Company, Point Beach Nuclear Power Station (WEP/WIS), the Virginia Electric and Power Company, Surry Nuclear Power Station (VPA), or the Consolidated Edison Company, Indian Point Plant No. 2 (IPP), and possibly future plants following them. The program can be utilized as a tool for various types of accident analyses and control studies, including Startup of an Inactive Reactor Coolant Loop, Loss of Reactor Coolant Flow, Reactivity Insertion Incidents, the Steam Line Break Accident, and Steam Generator Tube Rupture Accident and others. (auth)

### Physics and Core Engineering

**23865** (BAW-10055) FUEL DENSIFICATION REPORT. Turner, R. A. (Babcock and Wilcox Co., Lynchburg, Va. (USA). Nuclear Power Generation Div.). Feb 1973. 71p.

The Regulatory Staff of the U. S. Atomic Energy Commission has concluded that adequate data are available to account for the effects of fuel densification in the safety evaluation of nuclear power reactors. Considerable reliance was placed on the direct application of data obtained from operating reactors. These reactors have been operated safely with densified fuel and collapsed cladding, and the Regulatory Staff has concluded that implementing the recommendations of their report, "Technical Report on Densification of Light Water Reactor Fuels," will provide increased assurance of safe operation of reactors in which fuel densification is expected to occur. The AEC's recommendations and guidelines have been implemented and are described. (auth)

**23866** (TRG-Report-2362) STRUCTURAL DESIGN CRITERIA IN THE CONTEXT OF STRENGTH, STIFFNESS, AND FATIGUE. Lawton, W. T. (United Kingdom Atomic Energy Authority, Risley (England). Reactor Group). 1972. 25p. (CONF-721006-4). Dep. NTIS (U. S. Sales Only).

From International Conference on Engineering of Fast Reactors for Safe and Reliable Operation; Karlsruhe, Federal Republic of Germany (F. R. Germany) (9 Oct 1972).

Economical and safe design of the structural components of a fast reactor demands a high degree of analytical insight and a detailed knowledge of material behavior. Particular account must be taken of the influence of elevated temperature and high fast neutron flux. Fast reactors pose problems which are not encountered to the same degree in other reactor systems. Incipient instabilities can arise in low pressure thin-walled structures and specific examples considered during the design of P. F. R. are quoted as illustrations. Thermal shock problems may be severe and require careful definition of operational transients. High density coolant flowing through relatively light structures provides conditions under which flow induced vibrations could prove troublesome. The development of design methods and criteria appropriate to high temperature operation and their compilation into code form is discussed. Attention is drawn to certain shortcomings in materials data, particularly on those properties which may be affected by the presence of a sodium environment. (auth)

### Containment Systems, Shielding, Waste Processing, and Radiation Protection

**23867** (ORNL-tr-2674) STUDIES ON PRESTRESSED CONCRETE NUCLEAR VESSELS. 2. Model Experiments on PCRV.

Kamiya, Y.; Nojiri, Y. Translated by Hisashi Kubota (Oak Ridge National Lab., Tenn.), from Konkurito Janaru; 10: No. 12, 11-22 (1972). 36p. Dep. NTIS.

A series of model experiments on prestressed concrete reactor vessels is summarized. The studies included both internal pressure and thermal stress experiments. (JWR)

**23868** (SZS-143, pp 19-23) SURFACE PROTECTION IN NUCLEAR POWER PLANTS. Grunert, H. Sep 1972. (In German).

In radioactive wastes and decontamination.

Surfaces of rooms and equipment in the nuclear part of nuclear power plants may be contaminated with radioactive materials. Therefore the surface material must be radiation resistant and easy to decontaminate. Paints and surface finishes used in the GDR for rooms and equipment as well as monolithio- and reinforced-concrete surfaces are discussed. Their properties, the technology of application and the testing procedures are pointed out. To achieve optimum surface protection certain requirements are necessary with regard to sub-surface preparation, observance of technology of application, and construction conditions. In determining the type of surface protection, it must be considered that on account of radiation exposure and classification of areas in a nuclear power plant maintenance work has to be performed under special conditions. (auth)

## Cooling Systems

*Refer also to abstract 22609.*

**23869** (CONF-720579-, pp 125-135) OUT LINE OF SODIUM COMPONENT TEST FACILITY. Yuasa, Y. 1972.

From Meeting of Specialists on Sodium Combustion and its Extinguishment; Techniques and Technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22-25, 1972.

The design of a large sodium component test facility constructed in Japan for the purpose of full-scale performance testing of JOYO reactor components is described. Information on the status of proposed tests is tabulated. (LCL)

**23870** (FRNC-CONF-35) MOCKUP STUDIES OF THE RESPONSE OF PWR INTERNAL STRUCTURES TO RANDOM EXCITATIONS INDUCED BY FLOW. Dubourg, M. (Societe Franco-Americaine de Constructions Atomiques, Courbevoie (France)). 1972. 4p. (In Frence). (CONF-720648-6). Dep. NTIS (U.S. Sales Only).

From 12th meeting on hydraulics; Paris, France (6 Jun 1972).

Two methods were used in the research and test program. In the first one, separate measurements of the physical properties of the structures (natural frequency, natural mode, damping, etc.) and of the hydraulic excitations produced by the flow were performed. The structural response to random excitation was determined analytically using the Powell method. In the second one, direct measurements of the structural response to hydraulic excitation were made. The characteristics of the 1 : 8 scale model, the similarity conditions, and the instrumentation used are also described. (FR)

**23871** (FRNC-CONF-36) HYDROTECHNICAL PROBLEMS ASSOCIATED WITH NUCLEAR REACTOR PRIMARY PUMPS. Lepert, M.; Cahet, M.; Bertrand, M. (Establissements Pompes Guinard, Saint-Cloud (France)). 1972. 10p. (In French). (CONF-720648-9). Dep. NTIS (U. S. Sales Only).

From 12th meeting on hydraulics; Paris, France (6 Jun 1972).

The results of an experimental study of a prototype pump and motor set for PWR and BWR plants are presented. The pump ratings were: discharge: 7000 m$^3$/hr, head: 150 m, output: 2800 kW (hot water operation), inlet pressure: 130 bars, temperature: 300°C. Basic hydrotechnical problems were associated with the rotating shaft seal, hydraulic thrust, and hydrostatic bearing operation in hot water. (FR)

**23872** (JAERI-M-4798) CODE "APS" FOR THE ANALYSIS OF PIPING STRESS. Muto, Y. (Japan Atomic Energy Research Inst., Tokyo). Apr 1972. 32p. (In Japanese). NTIS (U.S. Sales Only).

In nuclear reactors and other industrial plants, with high-pressure coolants, larger thermal and pressure stresses are induced in the piping systems. These stresses and reaction forces at the anchors present considerable engineering problems in their design. The code "APS" (Analysis of the Piping Stress) was prepared to analyze these phenomena. The method of analysis is based on that of L.G. Peck et al., and the programming work was made by Century Research Center Company. The code is capable of calculation of the forces, stresses, deflections and reaction forces due to the thermal expansion and internal and external pressures in the piping system, which consists of given numbers of straight pipes, quarter-circular pipes, anchors and branches. The time required per calculation is about 1 minute. (auth)

**23873** (LIB/Trans-452) SAFETY ANALYSIS OF REACTOR PRESSURE VESSELS. Bartholome, G.; Dorner, H. Translated by K. Cecers (Australian Atomic Energy Commission Research Establishment, Lucas Heights) from Nucl. Eng. Des.; 20: 201-213 (1972). 26p. Dep. NTIS (U. S. Sales Only).

An evaluation of the safety of nuclear reactor pressure vessels for pressurized water reactors to resist fracture is an important feature in ensuring nuclear reactor safety. This evaluation is performed using fracture mechanics. The linear, elastic and plastic stress distributions for plane stress and plane strain conditions are derived for the different modes of fracture. The concepts of the linear elastic fracture mechanics and of the crack-opening method are shown. A critical analysis of crack growth and of stress corrosion cracking extends the use of fracture mechanics. Design and calculation of reactor pressure vessels using brittle fracture concepts, estimation of permissible crack sizes for the specification of standards for inspection, hydrostatic pressure test and recurring inspections, and evaluation of the operating performance and life expectancy of nuclear reactor pressure vessels including crack growth and stress corrosion cracking are technical applications of fracture mechanics studies of reactor pressure vessels. Using the above derived data, the safety of reactor pressure vessels against fracture is shown by means of: crack size—stress diagrams; brittle fracture diagrams and ductile fracture diagrams, and operating stress diagrams. (auth)

**23874** (LIB/Trans-482) VIBRATION PROBLEMS IN HEAT-EXCHANGERS OF THE CENTRAL NUCLEAR POWER STATION E.D.F.3. Coursimault, J.; Chabrerie, J. Translated by K. G. McLaren from Houille Blanche; 26: No. 5, 429-438(1971). 24p. Dep. NTIS (U. S. Sales Only) $3.25.

Modifications made to the EDF3 plant heat exchangers in 1969 led to the occurrence of vibrations under certain operating conditions, typically in the form of acoustic resonances and mechanical vibrations in the CO$_2$ exchanger circuits. The theoretical and experimental research into these effects, and the remedies adopted are described. The principal research and the results obtained are presented. (FR)

**23875** (LIB/Trans-497) CONTROL OF THE WATER-STEAM CIRCUIT OF A NUCLEAR POWER STATION. Barber, P. Translated by N. S. Stewart from Bull. Inform. Sci. Tech. (Paris); No. 167, 21-27(1972). 11p. Dep. NTIS (U. S. Sales Only) $3.00.

The logical process leading to the choice of control system for the water-steam circuit of a power station is exposed. Particular attention is given to the problems of dimensions which arise in the case of the steam generator of a high-temperature reactor. (auth)

**23876** (ORNL-4831) DEVELOPMENT OF THE VARIABLE-GAP TECHNIQUE FOR MEASURING THE THERMAL CONDUCTIVITY OF FLUORIDE SALT MIXTURES. Cooke, J. W. (Oak Ridge National Lab., Tenn.). Feb 1973. Contract W-7405-eng-26. 114p. Dep. NTIS. $5.45.

The development and evaluation of the variable-gap technique for measuring the thermal conductivity of molten fluoride salts is described. A series of measurements were made of the conductivities of several substances (Ar, He, H$_2$O, Hg, and liquid and solid heat-transfer salt) over a wide range of conductivities [$0.4 \times 10^{-3}$ to $100 \times 10^{-3}$ W cm$^{-1}$ (°C)$^{-1}$] and temperatures (40 to 950°C). The deviations of the results from published values averaged ±5%. The study demonstrates the accuracy and outstanding versatility of the variable-gap technique. (auth)

**23877** (TDA-TR-1) PROTECTION AGAINST PIPE WHIP RESULTING FROM PIPING RUPTURES. (Tennessee Valley Authority, Chattanooga; Duke Power Co., Charlotte, N. C.; American Electric Power Service Corp., New York). Jan 1973. 33p. Dep. NTIS.

The effects of pipe whip following piping ruptures in pressurized water and boiling water reactors are studied. The effects of such phenomena on the capability of engineered safeguard systems to perform in the case of a loss of coolant accident (LOCA) are evaluated. For ruptures which do not require the operation of engineered safeguard systems, criteria and methods are established to assure a LOCA does not occur as a secondary effect. (JWR)

## Fuel Systems and Components

*Refer also to abstracts 22278 and 23733.*

**23878** (ANL-7805) FAILURE MECHANISMS FOR INTERNALLY PRESSURIZED THIN-WALL TUBES AND THEIR RELATIONSHIP TO FUEL-ELEMENT FAILURE CRITERIA. Yaggee, F. L.; Li, C. Y. (Argonne National Lab., Ill.). Dec 1972. Contract W-31-109-Eng-38. 43p. Dep. NTIS $4.00.

Tube creep-to-rupture data for internally pressurized thin-wall tubes are reviewed and analyzed. Two failure mechanisms are apparent: (a) failure controlled by mechanical instability (transgranular), and (b) failure controlled by grain-boundary sliding (intergranular). The dependence of the failure mode and the strain at failure of a fuel-element cladding on stress, temperature, strain rate, and method of loading (gas pressure versus fuel swelling) are discussed. The experimental results are also presented with reference to their applicability in the formulation of fuel-element failure criteria. (auth)

**23879** (ANL-7963) INHERENTLY SAFE FUEL DEVELOPMENT: PRELIMINARY ANALYSES AND RECOMMENDATIONS. Roberts, J. T. A.; Eggen, D. T.; Livengood, C. D.; Trantina, G. G.; Stahl, D.; Lambropoulos, P. P., Neimark, L. A.; Shum, R. H.; Stevenson, M. G.; Huebotter, P. R. (Argonne National Lab., Ill.). Nov 1972. Contract W-31-109-eng-38. 61p. Dep. NTIS.

A preliminary analysis was made of fuel-element design concepts that would result in inherent safety of a fast-reactor core during a power-ramp accident. The designs that were most feasible used natural fuel phenomena, namely, solid-fuel expansion on heating and fuel-fission-gas expansion and frothing on melting. The former requires a bottom plenum design, whereas the latter can operate with either a top or bottom plenum but preferably a bottom plenum. Preliminary calculations, which used advanced fuel behavior and safety codes, established the probable behavior of fuel elements that incorporate these concepts and the effect of their actuation on hypothetical 1 and 5 $/sec power ramps occurring in the FFTF core. Based on the results, recommendations are made for future experimental and analytical work on inherent fuel-element safety. (auth)

**23880** (ANL-EBR-64) STUDY OF THE LIFE-I CODE. Chang, L. K. (Argonne National Lab., Ill; Argonne National Lab., Idaho Falls, Idaho). Jan 1973. Contract W-31-109-eng-38. 60p. Dep. NTIS $5.00.

LIFE-I is a FORTRAN-IV computer code that is capable of predicting behavior of fuel elements in a fast reactor. The logic, the numerical techniques, and the methods of solution employed by the code are presented, and the functions of the MAIN program and each of the subroutines are discussed. The computer program examined is based on the version existing in December 1970. (auth)

**23881** (ASEA-ATOM-TI-1) FAST REFUELING SYSTEM. (ASEA Atom, Vasteras (Sweden)). May 1972. 12p. Dep. NTIS (U. S. Sales Only).

Changing from refueling once a year to twice a year will improve burnup about 10%. A fast refueling system has been developed by ASEA-ATOM and AB Atomenergi. Fueling is expected to take place during a weekend shutdown. (Sw)

**23882** (EURFNR-1036) DESIGN, IRRADIATION, AND POST-IRRADIATION EXAMINATION OF THE IRRADIATION EXPERIMENT MOL 8A. Herrmann, H.; Hoffmann, H.; Geithoff, D. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Material und Festkoerperforschung). Jun 1972. 72p. (KFK-1520). Dep. NTIS.

Work performed under United States-Euratom Fast Reactor Exchange Program.

The irradiation experiment Mol 8A consisted of the irradiation of 2 pins in the BR 2 reactor. All thermal neutrons were absorbed with a Cd shield in order to produce a fast neutron irradiation. The pins consisted of $(U,Pu)O_2$-pellets and of cladding out of austenitic steel. The burnup of 50,000 MWd/t heavy atoms was reached with a rod power of 400-500 W/cm and a cladding outer temperature of maximum 650°C. The aim of the experiments, the pin design, the construction and specification of the pins, the preparation of the specimens, the irradiation history and the whole postirradiation examination are presented in documentary form. Since the postirradiation examinations were done in a shortened form, the irradiation experiment was classified as a performance test. The maximum diameter increase of the pins was 0.25% and 0.5% ($\phi t \simeq 10^{22}$ n/cm$^2$ and $7 \cdot 10^{21}$ n/cm$^2$ respectively; $E > 0.1$ MeV). The corrosion attack of the cladding (in the region of maximum burnup) was 30 μm and this value lies within the specifications. (auth)

**23883** (KFK-1729) BREDA: A MATHEMATICAL MODEL FOR THE DESCRIPTION OF FUEL PIN DEFORMATION (LMFBR) UNDER TRANSIENT CONDITIONS. Kuczera, B. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). Dec 1972. 48p. (In German). Dep. NTIS (U. S. Sales Only) $4.50.

BREDA is part of a computer code system designed for the overall analysis of hypothetical accidents in LMFBRs. The model predicts the behavior of a single fuel pin during fast reactor transients. Both the material displacement and change in pin geometry cause a feedback to the nuclear kinetics and thermodynamics of the power excursion. The calculations of the pin behavior are based on the thermoelastic stress-strain relations, the clad tube is treated as a material with elastic, perfectly plastic properties. Molten fuel can cause pressurizing in the pin. There is a pin burst criterion introduced. When it is exceeded loss of pin integrity is announced. In a sample problem the experiment S-3 (TREAT) is analyzed. (auth)

**23884** (RD/B/N-2434) FLOW-INDUCED VIBRATION OF A.G.R. FUEL PINS. Part 1. Theory. Durrans, R. F. (Central Electricity Generating Board, Berkeley (England). Berkeley Nuclear Labs.). Oct 1972. 30p. (RPC/OPT/VSG/P-(72)265). Dep. NTIS (U. S. Sales Only).

The vibration response of A.G.R. fuel pins to the random pressure field produced by the highly turbulent gas flow through the fuel channels is considered. The methods used by Chen and Wambsganss to predict the response of smooth rods subject to axial water flow are applied to A.G.R. fuel pins where the rods are ribbed and the fluid is a dense gas. A response equation is derived for transverse ribbed fuel and a functional dependence of response on gas density and velocity is predicted which agrees with experiment. The theory is extended to the case of multi-start fuel pins where there is the additional complication of a swirl component of velocity. A slight increase in response is predicted. (auth)

**23885** (RDT-P-4-4-T(2-73)) ELECTRIC HEATERS: SIMULATED PRESSURIZED WATER REACTOR FUEL PINS. (Division of Reactor Development and Technology (AEC), Washington, D. C.). Feb 1973. 22p. RSO.

The standard establishes requirements for performance, fabrication, inspection and test, and quality assurance for single and dual sheathed electric heaters simulating pressurized water reactor (PWR) fuel-pin configurations which are used for heat transfer and other studies related to water-cooled fuel. (FS)

**23886** (WCAP-3385-33) SAXTON PLUTONIUM PROJECT QUARTERLY PROGRESS REPORT FOR THE PERIOD ENDING SEPTEMBER 30, 1972. Goodspeed, R. C. (Westinghouse Electric Corp., Pittsburgh, Pa. Nuclear Fuel Div.). [nd]. Contract AT(11-1)-3044. 27p. Dep. NTIS.

The Saxton Plutonium Project is concerned with developing information on the utilization of Pu-enriched fuels in pressurized water reactors. The program includes design, fabrication, operation, and post-irradiation examination of a partial Pu core. During July to Oct. 1972, a post-irradiation examination sampling plan was internally approved and sent to the AEC for review, fuel shipments to the Battelle Memorial Institute (BMI) hot cell facility for the end-of-life post-irradiation examination program were completed, the preparation of BMI hot cells continued, and a Saxton Core II nuclear operations summary emphasizing pre- and post-midlife shutdown core physics measurements was prepared. This nuclear operations summary is included. (LCL)

## *Operation and Economics*

**23887** (AEC-tr-7407) ECONOMIC CRITERIA OF THE EFFICIENCY OF CONSUMPTION OF NUCLEAR FUEL IN REACTORS. (Gosudarstvennyi Komitet Po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Energeticheskii Institut). Translation of Report FEI-286. 1971. 15p. Dep. NTIS.

Determination of the price of uranium and the associated cost of plutonium is given on the basis of concepts regarding the limited resources of cheap uranium. These values are used to formulate the economic criteria for the optimization of reactors and several quantitative estimates are made. (auth)

**23888** (AECL-4304) ADVANCED HWR POWER PLANTS. Lewis, W. B. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.). Nov 1972. 10p. (CONF-720817-1; DL-110). Dep. NTIS (U. S. Sales Only). AECL $0.50.

From Conference on Nuclear Power for Tomorrow; Atlantic City, New Jersey, United States of America (USA) (22 Aug 1972).

Heavy-water reactors that are near-breeders can be alternatives for fast breeder reactors with the capability of meeting all the world's needs for power for many centuries. The Canada Deuterium Uranium (CANDU) and Steam-Generating Heavy-Water (SGHW) reactors are the only types of heavy-water reactor established for high-power generating stations. CANDU reactors now operating and under construction in large unit sizes are fueled with natural uranium and cooled and moderated with $D_2O$, meeting the requirements of utilities desiring a minimum of enrichment together with an attractive capital cost. Possible modifications to design are the use of boiling light water and organic coolant, and thorium fuel cycles. Heavy-water reactors have a worldwide distribution. They can be classified as follows: (1) zero energy lattice and reactor physics research reactors; (2) high flux materials test, neutron beam and isotope production reactors; (3) engineering test reactors with high temperature loops; (4) demonstration power reactors; (5) prototype power reactors; and (6) commercial power reactors. Operating experience with the large 540 MW(e) commercial units in Canada has been satisfactory. (auth)

**23889** (BMBW-FBK-72-23) CONSTRUCTION, START-UP, AND FIRST PERIOD OF OPERATION OF THE AVR EXPERIMENTAL POWER STATION. Engelhard, J. (Arbeitsgemeinschaft Versuchs-Reaktor G.m.b.H., Duesseldorf (West Germany)). Dec 1972. 258p. (In German). Dep. NTIS (U. S. Sales Only).

The AVR experimental power plant was equipped with a high-temperature pebble-bed reactor, thus representing the first reactor of the pebble-bed type. Information is presented on the construction and start-up of that plant up to when it was handed over to AVR GmbH. After a brief description of the power plant and a survey of all events by means of a time table, the experience achieved with the various components of the plant is explained. In spite of difficulties and delays of varying magnitudes during the construction period the results of the start-up and power operation give sufficient evidence that the pebble-bed reactor fulfills all anticipations. The project cost and financing are listed. (auth)

**23890** (RT/EC-(72)3) FORECASTS OF MARKETS AND INDUSTRIES IN ITALY FOR NUCLEAR REACTOR FUEL CYCLE SERVICES. Ambrosini, G.; Cicognani, G.; Comellini, O.; Valant, P.; Venditti, P.; Zironi, I. (Comitato Nazionale per L'Energia Nucleare, Rome (Italy)). 23 Oct 1972. 149p. (In Italian). Dep. NTIS (U. S. Sales Only) $9.50.

On the basis of ENEL's forecasts regarding the development of nuclear power in Italy until 1990, with extrapolations up to 2010, the evolution of the domestic market for the main nuclear reactor fuel cycle services is evaluated. In connection with similar estimates concerning the Western European market, and taking into account certain cost functions for the abovementioned services, a series of considerations are presented on the development of Italian industry in the nuclear fuel cycle field. (auth)

## *Safety and Siting*

**23891** (BC-TOP-3(Rev. 1)) TORNADO AND EXTREME WIND DESIGN CRITERIA FOR NUCLEAR POWER PLANTS. Shanahan, J. A. (Bechtel Corp., San Francisco, Calif.). Dec 1972. 146p.

Nuclear power plant design criteria for tornados and extreme winds are presented. Included are data, formulas and procedures for determining maximum wind loading on structures and parts of structures. Standard wind-generated missiles are identified and characterized. Criteria are also given for determining whether or not other objects can become wind-generated missiles and if their damage potential would be less or greater than that of the standard missiles specified. Many examples and a commentary to facilitate application and understanding of these criteria are included. (auth)

**23892** (CONF-720579) SODIUM COMBUSTION AND ITS EXTINGUISHMENT: TECHNIQUES AND TECHNOLOGY. MEETING OF SPECIALISTS, RICHLAND, WASHINGTON, MAY 22-25, 1972. (Hanford Engineering Development Lab., Richland, Wash). 1972. 174p. Dep. NTIS.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Eleven papers were presented at the conference. A separate abstract was prepared for each paper. (LCL)

*For abstracts of individual papers see: 23869, 23893–23899, 23990, 23991, and 24180.*

**23893** (CONF-720579-, pp 19-38) REVIEW OF CNEN ACTIVITIES IN THE FIELD OF SODIUM FIRES. Pec, Progetto; Sin, Progetto (C. S. N., Casaccia, Rome). 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22-25, 1972.

The main experimental sodium facilities of the Fast Reactor Program at C. N. E. N.'s Casaccia Nuclear Research Center are described. Information is included on: equipment, materials, and methods used to detect Na leaks and fires and to extinguish Na fires, and the control and effects of Na combustion products. (LCL)

**23894** (CONF-720579-, pp 39-61) CEA POSITION PAPER SODIUM COMBUSTION AND ITS EXTINGUISHMENT: TECHNIQUES AND TECHNOLOGY. Sauvage, M.; Fruchard, Y. (C.E.N., Cadarache, France; C.E.N., Saclay, France). 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22-25, 1972.

C. E. A. experience with equipment and methods for the detection of Na leaks and fires is reviewed. To ensure the surveillance of buildings and galleries containing Na piping the generalized use of flame photometer is proposed. Similarly, C. E. A. research on methods for extinguishing Na fires is discussed including the testing of various powders for Na fire extinguishment. A powder of sodium chloride base was selected as the extinguishing powder on the Phenix reactor. (LCL)

**23895** (CONF-720579-, pp 111-120) UKAEA EXPERIENCE IN THE DETECTION OF LIQUID METAL LEAKS. Kirk, J. 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22-25, 1972.

Fourteen years of experience at the Dounreay Experimental Reactor Establishment with the handling of large quantities of liquid metal are reviewed. During that time 5 relatively small leaks from operating reactor circuits occured and resulted in refined methods for leak detection. Operating experience with 7 detection methods, i.e., conduction probes, eddy current or induction devices, radiation detectors, thermocouples, flame photometers, smoke detectors, and current level indication, is summarized. Recommendations are made for the use of a particular method or combination of specific detectors for leak detection in jacketed, partially jacketed, box-contained, and uncontained circuits. (LCL)

**23896** (CONF-720579-, pp 121-123) DETECTION OF SODIUM FIRES RELIABILITY OF PRESENT METHODS. Bulmer, G. H. 1972.

From Meeting of specialists on sodium combustion and its extinguishments: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22-25, 1972.

Tests were performed to assess the relative sensitivity of three types of smoke detectors, i.e. photoelectric, laser beam, and ionization, to products of sodium combustion. It was concluded that the photoelectric type is best for detecting sodium oxides. A single laser unit could be used for the surveillance of large areas, but the laser beam would have to pass through 36 ft of sodium oxides of similar density to be of comparable sensitivity to a photoelectric smoke detector. The ionization type had poor sensitivity. Criteria for determining the reliability of a fire detection system is discussed briefly. Reliability is affected by detector position, ambient conditions of ventilation and radiation, and equipment failure. It is likely that two different types of fire detectors will be required to monitor different sections of an LMFBR. (LCL)

**23897** (CONF-720579-, pp 137-154) SECONDARY SODIUM CIRCUIT INTEGRITY AND FIRE FIGHTING PROCEDURES FOR THE UKAEA PROTOTYPE FAST REACTOR. Broadley, D. 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22-25, 1972.

The secondary sodium coolant circuit of the 600 MW(t) Prototype Fast Reactor (PFR) nearing completion at Dounreay is described. Experiments were performed to determine: the effects of burning Na on the PFR concrete floor and the existence of a Na/concrete reaction; if burning sodium will propagate to other secondary Na circuits; and a cheap and effective fire fighting method. Although only 30 liters of Na were used in the experiments, it is claimed that the results can be applied to larger fires. The test equipment and procedures are described. The concrete tests showed that the top inch of the concrete surface appeared to be damaged by heat, but did not combine chemically with the sodium. The test fire did not cause Na combustion in a nearby pipe. Vermiculite was the best extinguishant. In order to prevent burning below the vermiculite, the vermiculite was separated from the Na by being supported on a perforated plate and a small argon purge was applied to the space between the Na and the plate. (LCL)

**23898** (CONF-720579–, pp 169) SODIUM COMBUSTION PRODUCTS, CONTROLS AND EFFECTS EMERGENCY VENTILATION CONTROL. Bulmer, G. H. 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22–25, 1972.

The feasibility of recirculating through a foam-making apparatus a caustic liquor used in foam-form for sodium fire control is discussed. The purpose of this recirculation is to limit the foam disposal problem. (LCL)

**23899** (CONF-720579–, pp 171-174) EXTINGUISHMENT OF SODIUM FIRES. A Possible Technique for a Large Power LMFBR. Bulmer, G. H. 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22–25, 1972.

A method under consideration in the UK for protection against sodium fires in a sodium-cooled fast reactor complex is discussed. Sodium-containing equipment and circuits are to be contained in compartments not exceeding 3,000 $m^3$ in volume and a liquid nitrogen injection system is used for cooling effect and to reduce the oxygen content of the compartment atmosphere. (LCL)

**23900** (CONF-730304–2) LOCA MODELING ON THE HYBRID COMPUTER. Stone, R. S. (Oak Ridge National Lab., Tenn.). 1973. 10p. Dep. NTIS.

The hybrid computer is a working, symbiotic combination of an analog and a digital computer. The combination offers unique advantages in speed and stability when used for the analysis of large space-time dependent systems. Application to the fuel pin heatup problem addressed by the digital code THETA has produced a fast running, flexible alternative for looking at LOCA-related problems. (auth)

**23901** (IRS-F-12) RESEARCH REPORT. State: August 1972. (Technischer Ueberwachungs-Verein E. V., Cologne (West Germany). Institut fuer Reaktorsicherheit). Dec 1972. 189p. (In English and German). Dep. NTIS (U. S. Sales Only).

A compilation of research reports in the field of reactor safety in the Federal Republic of Germany is presented: RS and LRA research reports (sponsored by the Bundesministerium fuer Forschung und Technologie–BMFT) and GFK research reports of the Gesellschraft fuer Kernforschung. (GF)

**23902** (KURRI-TR-102) NONDESTRUCTIVE TESTING. Katsurayama, Y.; Tsujimoto, T. (Kyoto Univ. (Japan). Research Reactor Inst.). 1972. 64p. (In Japanese). Dep. NTIS (U. S. Sales Only).

Papers presented at the 5th Nondestructive Testing Conference held at the Reactor Research Institute of Kyoto University on October 9, 1971 are compiled. The theme of this conference was "Safety Tests after Reactor Operation Has Been Initiated." The plan of this program was to invite comments from representatives of the makers, users, and engineers. Four papers are presented describing tests from the user's side. These papers include "Line of Thought with Respect to In-service Inspection," "In-service Inspection of the JPDR," "In-service Inspection," and "Tests Conducted during the Common Use Period of the Nuclear Reactor Coolant Pressure Boundary." The papers that represent the contributions of the makers are concerned with "Experiences in In-service Inspection of Nuclear Reactor Pressure Containers," "Limitations and Problems Associated with Nondestructive Testing Employed in Safety Inspections of Nuclear Reactors after They Have Begun to Operate," and "Factory Inspection of Nuclear Reactor Pressure Containers." Finally there is a comment from a representative of the engineers describing the problems as seen from the viewpoint of the people actively engaged in the nondestructive testing of nuclear reactors. (TTT)

**23903** (RT/ING-(72)11) CONSIDERATIONS ON SODIUM FUEL INTERACTIONS RELATED TO FAST REACTOR SAFETY. Martini, M.; Sardone, D. (Comitato Nazionale Per l'Energia Nucleare, Rome (Italy)). 5 Jul 1972. 18p. (CONF-720665-1). Dep. NTIS (U. S. Sales Only).

From Reunion of specialists of CREST-ENEA on the combustible sodium interaction from the point of view of the safety of fast reactors; Grenoble, France (Jun 1972).

A brief analysis of the meaning of Design Basis Accident (DBA) as well as Operational Safety provides a better comprehension of the importance due to sodium fuel interaction (SFI) in Safety Analysis and Fast Reactor Design. With reference to typical accidents (divided into core and local accidents) which lead to SFI, the usefulness of studies on this subject is considered. (auth)

### *Steam and Power Conversion Systems*

**23904** (BMBW-FBK-72-28) DEVELOPMENT OF AN INTEGRATED HEAT EXCHANGER/STEAM GENERATOR IDA FOR SODIUM-COOLED FAST BREEDER REACTORS. FINAL REPORT. Albus, P.; Dumm, K.; Foerster, K.; Gerstler, R.; Hahn, G.; te HEESEN, E.; Keusenhoff, J.; Meineke, W.; Schellong, B.; Zipper, E. (Bundesministerium Fuer Bildung Und Wissenschaft, Bonn (West Germany)). Dec 1972. 65p. (In German). Dep. NTIS (U. S. Sales Only).

An attempt was made to find out whether a concept could be realized which would allow eliminating the intermediate heat exchange system which is normally used for sodium cooled power reactors. First it was proved that this was technically possible by using a reaction-proof steam generator, called IDA, with a triple-wall (steel-copper-steel) tube as a heat exchanging element. The triple-wall tube will exclude damage arising from direct contact between the radioactive sodium with the water-steam working medium. Technical and metallurgical investigations regarding the operation and failure characteristics of the triple-wall tube were performed. The test of a MW-prototype steam generator as well as the thermodynamic and functional studies on an IDA-nuclear power station with the same safety requirements as the SNR-300 reference reactor was found to be satisfactory. Based on the results, the idea of a fast breeder power reactor with a primary sodium heated reaction proof steam-generator seems to be basically possible, and a continuation of the development program aiming at a technically sound and economically interesting design is therefore considered to be a worthwhile policy. (auth)

## Commercial Power Reactors

*Refer also to abstracts 22719 and 24195.*

**23905** (NEDO-10569-A) BWR/6 NUCLEAR SYSTEM FROM GENERAL ELECTRIC: A PERFORMANCE DESCRIPTION. Fuller, E. D.; Finney, J. R.; Streeter, H. E. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). Apr 1972. 54p.

The General Electric Company (GE) has recently introduced a new boiling water reactor product line called BWR/6. This product line is the sixth major evolutionary step in the Boiling Water Reactor (BWR) since the initial design of Dresden 1 in 1955. The new product line incorporates a number of improvements which have been in the developmental, analysis and testing stages for several years. Consistent with General Electric's conservative design approach, each of the improved features has been fully analyzed and when necessary tested to confirm the adequacy of the selected design. With the incorporation of improved jet pumps, improved steam separators, increased number of fuel bundles, increased active fuel length, application of an 8 × 8 fuel bundle, improved moderator distribution, and resulting flatter power distributions, a target increase of 20% thermal power output has been achieved while maintaining given pressure vessel size. To reduce the impact on containment building and plant design, standard pressure vessel sizes and associated external recirculation loop sizes have been preserved. The same previously approved emergency core cooling system design concept represented in past BWR designs is incorporated in the BWR/6, which, when combined with reduced peak heat flux of the BWR/6 fuel, results in considerably reduced peak fuel temperatures in the loss-of-coolant accident (LOCA). A preliminary performance review of BWR/6 is presented to identify design characteristics which may be of special interest to the AEC and ACRS. The performance description is provided to facilitate later detailed review of Safety Analysis Reports incorporating the BWR/6 design. (auth)

**23906** (TID-8200(R27)) NUCLEAR REACTORS BUILT, BEING BUILT, OR PLANNED IN THE UNITED STATES AS OF DECEMBER 31, 1972. (Technical Information Center (AEC), Oak Ridge, Tenn.). 1972. 38p.

Information on the name, owner, location, principal nuclear contractor, reactor type, power ratings, and startup and shutdown dates for all United States reactors is tabulated. (JWR)

**23907** (TID-26268) GUIDE TO THE PREPARATION OF ENVIRONMENTAL REPORTS FOR NUCLEAR POWER PLANTS. (Directorate of Regulatory Standards (AEC), Washington, D. C.). Aug 1972. 104p. Dep. NTIS.

The format and content of environmental reports for nuclear power plants are described. (JWR)

**23908** (WASH-1208(3-73)) STATUS OF CENTRAL STATION NUCLEAR POWER REACTORS: SIGNIFICANT MILESTONES. (Division of Reactor Development and Technology (AEC), Washington, D. C.). 1 Mar 1973. 11p. Dep. NTIS $3.00.

## Control Elements, Systems, and Instrumentation

*Refer also to abstract 22506.*

**23909** (DOCKET-50029-229) YANKEE NUCLEAR POWER STATION. Proposed Change 106, Supplement 1. (Yankee Atomic Electric Co., Westboro, Mass.). 16 Mar 1973. 50p. Dep. NTIS $4.50.

Additional information on the redesign of the control rod shroud assembly for the Yankee Nuclear Power Station is presented. (JWR)

## Containment Systems, Shielding, Waste Processing, and Radiation Protection

*Refer also to abstract 22176.*

**23910** (BC-TOP-1(Rev.1)) CONTAINMENT BUILDING LINER PLATE DESIGN REPORT. Johnson, T. E.; Wedellsborg, B. W. (Bechtel Corp., San Francisco, Calif.). Dec 1972. 147p.

Design calculations and analytical techniques are provided for the following containment liner plate system components: liner plate and anchorage system; main steam pipe liner plate penetration; and polar crane bracket. The liner plate is described together with figures illustrating all the applicable details. Problem areas and factors affecting the liner plate and anchorage system design are covered in detail. The loads considered in the liner plate design are discussed and the approximate strains in the liner plate resulting from these loads are stated. (LCL)

**23911** (BC-TOP-5(Rev. 1)) PRESTRESSED CONCRETE NUCLEAR REACTOR CONTAINMENT STRUCTURES. Pusheck, B. N.; Duchon, N. B.; Gavankar, R.; Gendron, G. G.; Haavik, D. J.; Hill, H. T.; Kohli, T.; McCall, J. K.; Scribner, D. T.; Whitcraft, J. (Bechtel Corp., San Francisco, Calif.). Dec 1972. 284p.

The techniques and procedures used for the design of prestressed concrete nuclear reactor containment structures are discussed. A physical description of Bechtel designed containment structures is presented. The design bases and load combinations are given for anticipated conditions of service. Reference design documents which include industry codes, specifications, Safety Guides, Bechtel Topical Reports and additional criteria as appropriate to containment design are listed. Stepwise procedures typically followed by Bechtel for design of containments are discussed and design examples are presented. A description of currently used analytical methods and the practical application of these methods for containment design is also presented. The principal containment construction materials are identified and codes of practice pertaining to construction procedures are listed. Preoperational structural testing procedures and post-operational surveillance programs are furnished along with results of tests on completed containment structures. (auth)

**23912** (WCAP-7952) IODINE REMOVAL BY SPRAY IN THE SALEM STATION CONTAINMENT. Kemper, R. M. (Westinghouse Electric Corp., Pittsburgh, Pa. Nuclear Energy Systems Div.). Aug 1972. 79p.

A comprehensive mathematical model is developed to describe the absorption of elemental iodine vapor from the containment atmosphere by the containment spray system. Specifically, this model includes the effects of drop size by considering the complete spectrum of drop sizes emitted by the containment spray nozzles, condensation of steam on the spray drops, coalescence of drops, and the mass transfer resistance in the liquid phase of the drops. The model is shown to be conservative by theoretical considerations in the derivation, by comparison with alternate models, and by comparison with experimental data. The model is then applied to the Salem Station containment. Minimum performance values are used for all parameters which enter the analysis. This evaluation of the iodine removal effectiveness of the containment spray system gives an exponential removal coefficient, $\lambda_s$, of 35/hr. Although this value represents a conservative evaluation of the spray system under the most adverse conditions, a design value of $\lambda_s = 29$/hr is established by adding additional safety margins to the input parameters. (auth)

## Cooling Systems

**23913** (SZS-143, pp 8-18) RESULTS AND EFFECTS OF VARIOUS PROCEDURES FOR THE DECONTAMINATION OF THE PRIMARY CIRCUIT OF A PRESSURIZED WATER REACTOR. Legler, D. (VEB Kernkraftwerke, Greifswald, Ger.). Sep 1972. (In German).

In radioactive wastes and decontamination.

On the basis of a three-stage procedure developed at KKW Rheinsberg several decontaminations of the primary circuit were performed since 1968. The results obtained are analyzed and discussed under several points of view. The different possibilities of waste water treatment and waste disposal are also considered. Conclusions are drawn for future decontamination work at the Rheinsberg Plant and the nuclear power plant which is under construction. (auth)

**23914** (ZJE-128) REMOTE CORROSION MEASUREMENTS CARRIED OUT DURING COMPLEX TESTS OF THE A-1 REACTOR. Beran, J.; Ripka, J.; Sulc, J.; Cerny, K. (Skoda Works, Pilsen (Czechoslovakia). Nuclear Power Construction Dept.). 1972. 28p. Dep. NTIS (U. S. Sales Only).

Remote corrosion measurements in the A-1 reactor are useful to the supervision of corrosion in the heavy water circuit and to the control of inhibitor dosage. The corrosion environment consists of heavy water, saturated with carbon dioxide at a temperature of 90°C and pressure of 65 atm. It circulates in the primary circuit at a velocity up to 3 m/sec, water temperature varies from 40 to 90°C. As a basis for this measurement and control, corrosion probes placed in piping of the heavy-water circuit out of the reactor are used. Each probe is used for two types of measurements: instantaneous corrosion rate and instantaneous corrosion attack behavior. For measurement of the instantaneous corrosion rate the method of polarization resistance of Stern and Geary is used. Determination of corrosion attack behavior is carried out on the basis of current transients observed in a macroelement, which consists of two electrodes, both made from the same metal of interest. (auth)

## Fuel Systems and Components

**23915** (GU-5287) DRESDEN I PLUTONIUM RECYCLE PROGRAM. Semiannual Report for the Period Ending June 30, 1972. Hamilton, G. (Gulf United Nuclear Fuels Corp., Elmsford, N. Y.). Jan 1973. Contract AT(11-1)-2210. 59p. Dep. NTIS.

Reactor operations during Cycle 7 and Cycle 8 are summarized. The performance of the mixed oxide assemblies is evaluated. The results of fuel inspections are presented. Future plans and current design calculations on program changes are described. (JWR)

**23916** (GU-5289) PLATR CRITICAL EXPERIMENTS ON MIXED OXIDE FUEL ASSEMBLIES FOR BWR's AND COMPARISON WITH CALCULATIONS. Buck, P.; Brooks, W.; Fass, E. (Gulf United Nuclear Fuels Corp., Elmsford, N. Y.). Jan 1973. Contract AT(11-1)-2210. 42p. Dep. NTIS.

The experiments and calculations performed to determine the nuclear characteristics of BWR fuel assemblies containing mixed uranium and plutonium oxides are summarized. The fuel assemblies investigated were similar to the 11 plutonium recycle assemblies delivered by Gulf United Nuclear Fuels Corporation as part of the reload batch for Cycle 7 of the Dresden Unit I reactor. The experiments were performed in the Pawling Lattice Test Rig (PLATR). The experimental method which was used to determine $k_\infty$ of the test fuel assemblies was the void substitution technique, in which the $k_\infty$ of a test assembly is reduced to 1.0000 by addition of a poison to its moderator. The determination of $k_\infty = 1.000$ is made by comparing the reactivity of the poisoned test assembly with the reactivity of a void substituted for it. Calculations of the $k_\infty$ for the test cell with and without the poison in the moderator provide a normalized value for the unpoisoned $k_\infty$, normalized to the known $k_\infty = 1.0000$ for the poisoned condition. During the course of the $k_\infty$ determinations, measurements were also made of the local power distribution within the test fuel assembly. The experimentally determined $k_\infty$ values were compared with calculations performed using the LOCALUX-4 code, which is one of the basic analysis tools at Gulf United for BWR assembly reactivity and depletion calculations. The values of $k_\infty$ calculated by LOCALUX-4 agree with experiments to within 5%. The experimentally determined local power and fission distributions were compared with calculations performed with the two-dimensional diffusion theory codes TWENTY-GRAND and PDQ. The average deviation between experiment and calculation is 4%. (auth)

## *Operation and Economics*

**23917** (DLCS-5000372) SHIPPINGPORT ATOMIC POWER STATION. Quarterly Operating Report, Third Quarter, 1972. (Duquesne Light Co., Shippingport, Pa. Power Stations Dept.). 1972. Contract AT(11-1)-292. 20p. Dep. NTIS.

The operation and maintenance of the Shippingport Power Station during the period July through September 1972 are summarized. (JWR)

**23918** (DOCKET-50010-131) DRESDEN NUCLEAR POWER STATION, UNIT 1. Appendix A of DPR-2, Proposed Change. (Commonwealth Edison Co., Chicago, Ill.). Feb 1972. 4p. Dep. NTIS.

Revised license specifications are presented concerning the temperature limits for the emergency steam condenser and flood analysis for the site. (DCC)

**23919** (DOCKET-50010-137) DRESDEN NUCLEAR POWER STATION, UNIT 1. Response to Noncompliance Items for DPR-2 Identified During November 28–December 1, 1972. (Commonwealth Edison Co., Chicago, Ill.). 23 Feb 1973. 23p. Dep. NTIS.

Information is presented concerning the maximum temperature limit for the emergency steam condenser shell-side water and the failure of the emergency diesel generator to Bus 15 circuit breaker. (DCC)

**23920** (DOCKET-50010-138) DRESDEN NUCLEAR POWER STATION, UNIT 1. Malfunction of Main Steam Isolation Valve. (Commonwealth Edison Co., Morris, Ill. (USA)). 5 Feb 1973. 2p. Dep. NTIS $3.00.

**23921** (DOCKET-50010-139) DRESDEN NUCLEAR POWER STATION, UNIT 1. Emergency Condenser Shell Side Water Temperature Exceeded Maximum of 100°F. (Commonwealth Edison Co., Chicago, Ill.). 3 Mar 1973. 2p. Dep. NTIS $3.00.

**23922** (DOCKET-50029-224) YANKEE NUCLEAR POWER STATION. Proposed Change 106. (Yankee Atomic Electric Co., Westboro, Mass.). 5 Feb 1973. 5p. Dep. NTIS.

Revised technical specifications are presented concerning the installation of stainless steel shroud tubes and support plates for control elements. (DCC)

**23923** (DOCKET-50133-111) HUMBOLDT BAY POWER PLANT, UNIT 3. Summary Evaluation Report. (Pacific Gas and Electric Co., San Francisco, Calif.). 15 Dec 1972. 63p. Dep. NTIS.

Additional information is presented concerning operations aspects of the reactor. (DCC)

**23924** (DOCKET-50133-114) HUMBOLDT BAY POWER PLANT, UNIT 3. Faulty Overcurrent Trip Delay Device in Circuit Breakers. (Pacific Gas and Electric Co., San Francisco, Calif.). 8 Mar 1973. 5p. Dep. NTIS $3.00.

**23925** (DOCKET-50155-138) BIG ROCK POINT NUCLEAR PLANT. Technical Specifications, Proposed Change 36. (Consumers Power Co., Jackson, Mich.). 2 Feb 1973. 6p. Dep. NTIS.

Revised technical specifications are presented concerning neutron sources for the reactor. (DCC)

**23926** (DOCKET-50155-139) BIG ROCK POINT NUCLEAR PLANT. Semiannual Operators Report 17, July 1–December 31, 1972. (Consumers Power Co., Jackson, Mich.). 28 Feb 1973. 65p. Dep. NTIS.

**23927** (DOCKET-50171-114) PEACH BOTTOM ATOMIC POWER STATION, UNIT 1. Semiannual Operations Report 67, July 1, 1972–December 31, 1972. (Philadelphia Electric Co., PA). 1972. 40p. Dep. NTIS $4.00.

**23928** (DOCKET-50206-189) SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1. Technical Specifications, Proposed Change 16. (Southern California Edison Co., Rosemead, Calif.). 1 Mar 1973. 7p. Dep. NTIS.

Revised specifications are presented concerning control requirements for Cycle 3 fuel densification effects. (DCC)

**23929** (DOCKET-50206-190) SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1. Earthquake of February 21, 1973. (Southern California Edison Co., Rosemead, Calif.). Mar 1973. 8p. Dep. NTIS $3.00.

**23930** (DOCKET-50206-191) SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1. No. 2 Diesel Generator. (Southern California Edison Co., Rosemead, Calif.). 8 Mar 1973. 2p. Dep. NTIS $3.00.

**23931** (DOCKET-50213-173) HADDAM NECK PLANT, UNIT 1. Malfunction of One of Three High Pressurizer Level Reactor Trip-Alarm Units. (Connecticut Yankee Atomic Power Co., East Hampton, Conn. (USA)). 22 Jan 1973. 2p. Dep. NTIS.

**23932** (DOCKET-50213-174) HADDAM NECK PLANT, UNIT 1. Operation Report 72-12 for the Month of December 1972. (Connecticut Yankee Atomic Power Co., East Hampton (USA)). 24 Jan 1973. 15p. (NYO-3144-79). Dep. NTIS.

**23933** (DOCKET-50213-180) HADDAM NECK PLANT, UNIT 1. Operations Report 73-1 for Month of January 1973. (Connecticut Yankee Atomic Power Co., East Hampton (USA)). 28 Feb 1973. 14p. (NYO-3144-80). Dep. NTIS.

**23934** (DOCKET-50213-181) HADDAM NECK PLANT, UNIT 1. AO-73-2, Faulty Light Sensitive Photo-Diode. (Connecticut Yankee Atomic Power Co., East Hampton (USA)). 2 Mar 1973. 2p. Dep. NTIS $3.00.

The replacement of a faulty light sensitive photo-diode in the pressure indicating system of the cooling system pressurizer is described. (DCC)

**23935** (DOCKET-50219-233) OYSTER CREEK NUCLEAR POWER PLANT, UNIT 1. Valve Testing Following Primary System Blowdown Occurrence of December 29, 1972. (Atomic Energy Commission, Washington, D. C.). 15 Feb 1973. 2p. Dep. NTIS.

**23936** (DOCKET-50219-239) OYSTER CREEK NUCLEAR POWER PLANT, UNIT 1. Fuel Channel Study Program. (Jersey Central Power and Light Co., Morristown, N. J.). 11 Jan 1973. 2p. Dep. NTIS.

**23937** (DOCKET-50220-122) NINE MILE POINT NUCLEAR STATION, UNIT 1. Request for Authorization to Make Changes. (Niagara Mohawk Power Corp., Syracuse, N. Y.). 31 Jan 1973. 15p. Dep. NTIS.

Information is presented concerning the use of Type 4 fuel element assemblies. (DCC)

**23938** (DOCKET-50220-125) NINE MILE POINT NUCLEAR STATION, UNIT 1. Seventh Semiannual Report of Operations, July 1, 1972–December 31, 1972. (Niagara Mohawk Power Corp., Syracuse, N. Y.). 28 Feb 1973. 36p. Dep. NTIS.

**23939** (DOCKET-50237-304) DRESDEN NUCLEAR POWER STATION, UNIT 2. Condenser Low Vacuum Scram Sensor Drift, January 23, 1973; HPCI Steamline Break Detection Sensor Drift. (Commonwealth Edison Co., Morris, Ill. (USA)). 24 Jan 1973. 4p. Dep. NTIS. $3.00.

**23940** (DOCKET-50244-142) ROBERT EMMETT GINNA NUCLEAR POWER PLANT, UNIT 1. Action to be Taken to Correct The Items on Noncompliance Brought to Attention Following Inspections October 30–November 3 and November 13–16, 1972. (Rochester Gas and Electric Corp., N. Y.). 15 Jan 1973. 25p. Dep. NTIS.

Additional information is presented concerning the reporting requirements for gaseous releases and operation procedures. (DCC)

**23941** (DOCKET-50244-145) ROBERT EMMET GINNA NUCLEAR POWER PLANT, UNIT 1. Semiannual Report 6, June 26–December 31, 1972. (Rochester Gas and Electric Corp., N. Y.). 27 Feb 1973. 97p. Dep. NTIS.

**23942** (DOCKET-50245-199) MILLSTONE NUCLEAR POWER STATION, UNIT 1. AO-73-1, Scram Time of Two Control Rods Too Slow. (Millstone Point Co., Hartford, Conn.). 19 Mar 1973. 1p. Dep. NTIS $3.00.

**23943** (DOCKET-50249-189) DRESDEN NUCLEAR POWER STATION, UNIT 3. Check Valves 3-1601-31A and 31B Found to be Leaking Excessively. (Commonwealth Edison Co., Chicago, Ill.). 23 Feb 1973. 2p. Dep. NTIS.

**23944** (DOCKET-50254-168) QUAD-CITIES STATION, UNIT 1. Setpoint Drift of Switches dPIS-1-2353. (Commonwealth Edison Co., Cordova, Ill.). 26 Feb 1973. 1p. Dep. NTIS.

**23945** (DOCKET-50254-169) QUAD-CITIES STATION, UNIT 1. Setpoint Drift of Switch PS-1-261-30C. (Commonwealth Edison Co., Cordova, Ill.). 26 Feb 1973. 1p. Dep. NTIS.

**23946** (DOCKET-50254-170) QUAD-CITIES STATION, UNITS 1 AND 2. Semiannual Report, July 1, 1972–December 31, 1972. (Commonwealth Edison Co., Chicago, Ill.). 28 Feb 1973. 73p. (Docket-50265-159). Dep. NTIS.

**23947** (DOCKET-50254-172) QUAD-CITIES STATION, UNITS 1 AND 2. Setpoint Drift of Pressure Switches. (Commonwealth Edison Co., Cordova, Ill.). 2 Mar 1973. 2p. (Docket-50265-161). Dep. NTIS.

**23948** (DOCKET-50254-174) QUAD-CITIES STATION, UNIT 1. Setpoints of the Electromatic Relief Valves Drifted. (Commonwealth Edison Co., Cordova, Ill.). 7 Mar 1973. 3p. Dep. NTIS $3.00.

**23949** (DOCKET-50255-135) PALISADES PLANT. Steps Taken to Correct Item of Noncompliance Brought to Attention After Inspection on November 20, 21, and 22, 1972. (Consumers Power Co., Jackson, Mich.). 26 Jan 1973. 17p. Dep. NTIS.

Additional information is presented concerning the stock release of gaseous radioactive wastes. (DCC)

**23950** (DOCKET-50255-136) PALISADES PLANT. Monthly Primary and Secondary Radioactivity Report, January 1973. (Consumers Power Co., Jackson, Mich.). 27 Feb 1973. 3p. Dep. NTIS.

**23951** (DOCKET-50255-138) PALISADES PLANT. Technical Specifications, Change 4. (Directorate of Licensing (AEC), Washington, D. C.). 8 Mar 1973. 14p. Dep. NTIS.

Revised technical specifications are presented concerning power limits for operation. (DCC)

**23952** (DOCKET-50255-139) PALISADES PLANT. Steam Generator Tube Leakage, Additional Information. (Consumers Power Co., Jackson, Mich.). 6 Mar 1973. 4p. Dep. NTIS $3.00.

**23953** (DOCKET-50255-140) PALISADES PLANT. Modifications to Control Rod Drive Mechanism Clutch Assemblies. (Consumers Power Co., Jackson, Mich.). 8 Mar 1973. 7p. Dep. NTIS $3.00.

**23954** (DOCKET-50261-141) H. B. ROBINSON UNIT 2. Administrative Procedure Violation. (Carolina Power and Light Co., Raleigh, N.C.). 6 Feb 1973. 1p. Dep. NTIS.

**23955** (DOCKET-50261-149) H. B. ROBINSON UNIT 2. Request for Revision of Technical Specifications. (Carolina Power and Light Co., Raleigh, N. C.). 28 Feb 1973. 1p. Dep. NTIS.

Revised specifications are presented concerning surveillance test requirements. (DCC)

**23956** (DOCKET-50261-150) H. B. ROBINSON UNIT 2. Technical Specifications, Surveillance of Boron Concentration of Boron Injection Tank. (Carolina Power and Light Co., Raleigh, N. C.). 14 Mar 1973. 2p. Dep. NTIS $3.00.

Revised technical specifications are presented concerning surveillance requirements for boron concentration in the boron injection tank. (DCC)

**23957** (DOCKET-50263-179) MONTICELLO NUCLEAR GENERATING PLANT, UNIT 1. Provisional Operating License DPR-22, Amendment 3. (Northern States Power Co., Minneapolis, Minn.). 5 Feb 1973. 3p. Dep. NTIS.

Revised license specifications are presented concerning the use of uranium-235 in fission chambers during a refueling outage. (DCC)

**23958** (DOCKET-50263-189) MONTICELLO NUCLEAR GENERATING PLANT, UNIT 1. Operating Report 4, July–December 1972. (Northern States Power Co., Minneapolis, Minn.). 1972. 163p. Dep. NTIS $10.25.

**23959** (DOCKET-50265-162) QUAD-CITIES STATION, UNIT 2. Setpoint Drifts of Switches PS-2-261-30A, B, and D. (Commonwealth Edison Co., Cordova, Ill.). 26 Feb 1973. 2p. Dep. NTIS.

**23960** (DOCKET-50265-164) QUAD-CITIES STATION, UNIT 2. Drift of Two Primary Containment Isolation System Instruments. (Commonwealth Edison Co., Cordova, Ill.). 6 Mar 1973. 2p. Dep. NTIS $3.00.

**23961** (DOCKET-50265-165) QUAD-CITIES STATION, UNIT 2. Hydrogen Explosion, March 6, 1973. (Commonwealth Edison Co., Cordova, Ill.). 16 Mar 1973. 6p. Dep. NTIS $3.00.

**23962** (DOCKET-50266-103) POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2. Operation Report 5, July 1, 1972–December 31, 1972. (Wisconsin Electric Power Co., Milwaukee). 1 Mar 1973. 91p. (Docket-50301-87). Dep. NTIS.

**23963** (DOCKET-50266-104) POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2. Containment Purge Supply Valve Switch Malfunction. (Wisconsin Electric Power Co., Milwaukee). 9 Mar 1973. 2p. (DOCKET-50301-89). Dep. NTIS $3.00.

**23964** (DOCKET-50269-89) OCONEE NUCLEAR STATION, UNIT 1. Reactor Coolant Pump Motor Oil Leak and Resulting Fire. (Duke Power Co., Charlotte, NC). 26 Jan 1973. 5p. Dep. NTIS.

**23965** (DOCKET-50269-90) OCONEE NUCLEAR STATION, UNITS 1 AND 3. Inspection Reports 50-269/72-10 and 50-287/72-7. (Duke Power Co., Charlotte, N. C.). 15 Feb 1973. 37p. (DOCKET-50287-65). Dep. NTIS.

Information is presented concerning cooling system flow signal fluctuations during hot functional testing. (DCC)

**23966** (DOCKET-50269-91) OCONEE NUCLEAR STATION, UNIT 1. Technical Specifications Change Request. (Duke Power Co., Charlotte, N. C.). 15 Feb 1973. 7p. Dep. NTIS.

Results of the hot functional testing internals vibration monitoring program are presented. Revised specifications concerning the maximum power limit are requested. (DCC)

**23967** (DOCKET-50271-143) VERMONT YANKEE NUCLEAR POWER STATION. Abnormal Occurrence AO-73-04, Circuit Board Relay Replaced. (Vermont Yankee Nuclear Power Corp., Rutland). 26 Feb 1973. 2p. Dep. NTIS.

**23968** (DOCKET-50271-147) VERMONT YANKEE NUCLEAR POWER STATION. AO-73-06, Improper Flow Through Off-Gas Sample Monitoring System March 2, 1973. AO-73-07, Steam Leak Around Bonnet of Steam Exhaust Line Check Valve March 2, 1973. (Vermont Yankee Nuclear Power Corp., Rutland). 9 Mar 1973. 6p. Dep. NTIS $3.00.

**23969** (DOCKET-50271-148) VERMONT YANKEE NUCLEAR POWER STATION. Grapple Became Detached from Jib Crane Hoist Cable. (Vermont Yankee Nuclear Power Corp., Rutland). 6 Mar 1973. 2p. Dep. NTIS $3.00.

**23970** (DOCKET-50271-149) VERMONT YANKEE NUCLEAR POWER STATION. Operations Report 72-10, October 1972. (Vermont Yankee Nuclear Power Corp., Rutland). 5 Mar 1973. 29p. Dep. NTIS $3.50.

**23971** (DOCKET-50271-150) VERMONT YANKEE NUCLEAR POWER STATION. Operations Report 72-11, November 1972. (Vermont Yankee Nuclear Power Corp., Rutland). 5 Mar 1973. 27p. Dep. NTIS $3.50.

**23972** (DOCKET-50271-151) VERMONT YANKEE NUCLEAR POWER STATION. Operations Report 72-12, December 1972. (Vermont Yankee Nuclear Power Corp., Rutland). 5 Mar 1973. 21p. Dep. NTIS $3.25.

**23973** (DOCKET-50271-152) VERMONT YANKEE NUCLEAR POWER STATION. Abnormal Occurrence AO-73-08, Time Delay Relay Failed to Actuate in Specified Time. (Vermont Yankee Nuclear Power Corp., Rutland). 8 Mar 1973. 3p. Dep. NTIS $3.00.

**23974** (DOCKET-50271-155) VERMONT YANKEE NUCLEAR POWER STATION. Technical Specifications, Proposed Change 9. (Vermont Yankee Nuclear Power Corp., Rutland). 19 Mar 1973. 3p. Dep. NTIS $3.00.

Revised technical specifications are presented concerning release rates for radioactive effluents. (DCC)

**23975** (DOCKET-50275-31) DIABLO CANYON NUCLEAR POWER PLANT, UNITS 1 AND 2. Faulty Overcurrent Trip Delay Device in Circuit Breakers. (Pacific Gas and Electric Co., San Francisco, Calif.). 13 Mar 1973. 5p. (DOCKET-50323-30). Dep. NTIS $3.00.

**23976** (DOCKET-50280-108) SURRY POWER STATION, UNIT 1. AO-S1-73-01-10, Transient Over-Pressurization of Nuclear Reactor Cooling System, January 28, 1973. (Virginia Electric and Power Co., Richmond). 13 Feb 1973. 8p. Dep. NTIS.

**23977** (DOCKET-50293-112) PILGRIM NUCLEAR POWER STATION. Deletion of Full Power Turbine Stop Valve Closure Test. (Boston Edison Co., Mass.). 25 Jan 1973. 2p. Dep. NTIS.

**23978** (DOCKET-50293-113) PILGRIM NUCLEAR POWER STATION. HPCI System Made Inoperable, January 16, 1973; Barton Differential Pressure Indicating Switch Out of Calibration, January 31, 1973; Barton Differential Pressure Indicating Switch Adjusted per Field Representative, January 31, 1973. (Boston Edison Co., Mass.). 9 Feb 1973. 8p. Dep. NTIS.

**23979** (DOCKET-50293-116) PILGRIM NUCLEAR POWER STATION. Abnormal Occurrence AO-72-19, RCIC System Became Inoperable, Corrective Action. (Boston Edison Co., Mass.). 10 Jan 1973. 2p. Dep. NTIS.

**23980** (DOCKET-50293-122) PILGRIM NUCLEAR POWER STATION. UO-73-3 Service Water Pump Failure. (Boston Edison Co., Mass.). 9 Mar 1973. 1p. Dep. NTIS $3.00.

**23981** (DOCKET-50293-123) PILGRIM NUCLEAR POWER STATION. UO-73-4, Failure of Motor on Steam Supply Valve to HPCI Turbine on February 17, 1973. Inadvertant Closure of Main Steam Isolation Valves. (Boston Edison Co., Mass.). 13 Mar 1973. 3p. Dep. NTIS $3.00.

**23982** (DOCKET-50295-84) ZION STATION NUCLEAR POWER PLANT, UNITS 1 AND 2. Information Relative to Apparent Violation of AEC Regulations Brought to Attention in Letter Dated November 27, 1972. (Commonwealth Edison Co., Chicago, Ill.). 22 Dec 1972. 34p. (DOCKET-50304-79). Dep. NTIS.

Additional information is presented concerning quality assurance procedures. (DCC)

**23983** (DOCKET-50309-94) MAINE YANKEE ATOMIC POWER STATION. Actions to be Taken to Correct Items of Noncompliance Brought to Attention Following Inspection October 10–13 and 23–24, 1972. (Maine Yankee Atomic Power Co., Westboro, Mass.). 12 Feb 1973. 21p. Dep. NTIS $3.25.

Additional information is presented concerning operational surveillance requirements and environmental monitoring requirements. (DCC)

**23984** (DOCKET-50309-97) MAINE YANKEE ATOMIC POWER STATION. High Pressure Turbine No. 1 Governor Valve Spring Retaining Bolt Failed. (Maine Yankee Atomic Powers Co., Wiscasset). 10 Mar 1973. 1p. Dep. NTIS $3.00.

**23985** (DOCKET-50321-70) EDWIN I. HATCH NUCLEAR PLANT, UNIT 1. Difference in Understanding of Meeting Held January 18–19, 1973. (Georgia Power Co., Atlanta). 15 Feb 1973. 3p. Dep. NTIS.

Additional information is presented concerning operations aspects for the reactor. (DCC)

**23986** (DOCKET-50409-38) LA CROSSE BOILING WATER REACTOR. Abnormal Occurrence No. 73-1, Containment Building Main Steam Isolation Valve Bypass Valve Positioner Failure. (Dairyland Power Cooperative, La Crosse, Wis.). 14 Feb 1973. 5p. Dep. NTIS.

**23987** (DOCKET-50409-40) LA CROSSE BOILING WATER REACTOR. Monthly Operating Report, December 1972. (Dairyland Power Cooperative, La Crosse, Wis.). 1972. Contract AT(11-1)-851. 30p. (DPC-851-51). Dep. NTIS $3.50.

## *Safety and Siting*

*Refer also to abstracts 22478, 22479, 22502, 22704–22706, 22771, and 22775.*

**23988** (AEC-tr-7398) LICENSING PROCEDURES UNDER ATOMIC LAW IN WEST GERMANY. Translated from German. Jul 1972. 24p. Dep. NTIS.

The West German "Law on the Peaceful Use of Nuclear Energy and Protection against its Dangers", i.e. the Atomic Law of Dec. 23, 1959, is discussed as to intent and the regulations therein for protection, licensing, liability and security, and provisions for punitive action and fines. The Atomic Law is viewed in relation to international radiation protection recommendations and international law. Procedures for licensing including the requirements for license applications, competence and activities of license examiners, time scheduling the licensing processes, and the safety analyses required are described. Safety criteria for reactor site selection and reactor design and construction, inspection during construction, and equipment and methods for protecting against both reactor operation accidents and out-of-reactor accidents are discussed. It is concluded that if all concerned continue to strive for the maximum possible safety, i.e. the protection of the population against any possible danger from peaceful uses of atomic energy, the licensing and surveillance procedures already developed should permit the safe construction and operation of nuclear power plants in West Germany. (LCL)

**23989** (BAW-1388) OCONEE I FUEL DENSIFICATION REPORT. (Babcock and Wilcox Co., Lynchburg, Va. (USA). Nuclear Power Generation Div.). Feb 1973. 45p.

An analysis of the fuel densification effects for the Oconee Nuclear Power Station, Unit Number I is presented, which supports the operation of Unit I at its rated power level of 2568 MW(t). (auth)

**23990** (CONF-720579–, pp 63-71) BEHAVIOR OF THE AEROSOLS OF A SODIUM FIRE IN A CLOSED SYSTEM. Colome, J. (SESR, Cadarache, France). 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22-25, 1972.

Experiments were performed to study the production, transport, and filtration of aerosols of a sodium fire in a closed system with and without enclosure ventilation. Spray fires and pool fires were investigated. The experiments determined the initial concentration of the aerosols, the proportions of the aerosols deposited on the bottom and on the walls of the enclosure, and the deposition of aerosol particles on the ventilation system filters. The ventilation system for the Phenix reactor was derived from these experiments and its schematic is presented. (LCL)

**23991** (CONF-720579–, pp 73-109) U. S. POSITION PAPER SODIUM COMBUSTION AND ITS EXTINGUISHMENT: TECHNIQUES AND TECHNOLOGY. Part I, Part II, and Part III. Morewitz, H. A.; (Atomics International, Canoga Park, Calif); Hilliard, R. K.; Yatabe, J. M.; Smith, F. A. 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

Sodium combustion and its extinguishment: techniques and technology. Meeting of specialists, Richland, Washington, May 22-25, 1972.

Sodium combustion and its extinguishment are discussed in terms of: the detection of leaks in liquid sodium systems; sodium fire prevention and extinguishment techniques; methods for fire protection used in US sodium facilities; testing of extinguishment methods; performance of extinguishment systems during a 100 liter spill in the US; the control and effects of sodium combustion products and environmental considerations related to this control; and methods for sodium residue removal and disposal with emphasis on EBR-II experience. It is concluded that environmental safety considerations related to the control of sodium oxides fumes and combustion products and to the disposal of sodium metal will have a significant impact on the design of LMFBR's. (LCL)

**23992** (CONF-720580-1) PREPARATION OF ENVIRONMENTAL IMPACT STATEMENTS AT OAK RIDGE NATIONAL LABORATORY. Browning, W. E. Jr. (Oak Ridge National Lab., Tenn.). 1971. Contract W-7405-eng-26. 31p. Dep. NTIS.

From 11th annual environmental and water resources engineering conference; Nashville, Tennessee, USA (31 May 1972).

Experience at Oak Ridge National Laboratory on assessment of potential environmental impacts of nuclear power plants and on preparation of Environmental Impact Statements required by the National Environmental Policy Act is described. (JWR)

**23993** (DOCKET-50003-155) INDIAN POINT STATION, UNIT 1. Topical Report on General Electric Motors Inside

Containment Low Pressure Core Cooling, Addendum. (Consolidated Edison Co. of New York, Inc., New York). 13 Feb 1973. 6p. Dep. NTIS.

Additional information concerning General Electric Motors inside the containment low pressure core cooling system for the Indian Point Station, Unit 1 is given.

**23994** (DOCKET-50010-136) DRESDEN NUCLEAR POWER STATION, UNIT 1. Final Hazards Summary Report, Proposed Modification 73-1. (Commonwealth Edison Co., Chicago, Ill). 1 Mar 1973. 7p. Dep. NTIS.

Revised information is presented concerning the quality assurance program for operation. (DCC)

**23995** (DOCKET-50010-140) DRESDEN NUCLEAR STATION, UNITS 1, 2, and 3. Quad-Cities Station, Units 1 and 2. Control Circuit Deficiencies. (Commonwealth Edison Co., Chicago, Ill.). 7 Mar 1973. 4p. (Docket-50237-303; Docket-50249-194; Docket-50254-173; Docket-50265-163). Dep. NTIS $3.00.

**23996** (DOCKET-50029-227) YANKEE NUCLEAR POWER STATION. Offsite Environmental Radiological Monitoring, July 1, 1972-December 31, 1972. (Yankee Atomic Electric Co., Westboro, Mass.). 1 Mar 1973. 12p. Dep. NTIS.

**23997** (DOCKET-50029-228) YANKEE NUCLEAR POWER STATION. Action to be Taken to Correct The Item of Noncompliance Brought to Attention Following Inspection of November 17, 1972. (Yankee Atomic Electric Co., Westboro, Mass.). 23 Jan 1973. 28p. Dep. NTIS $3.50.

Additional information is presented concerning the emergency core cooling system. (DCC)

**23998** (DOCKET-50133-113) HUMBOLDT BAY POWER PLANT, UNIT 3. Additional Information Concerning the Quality Assurance Program. (Pacific Gas and Electric Co., San Francisco, Calif.). 2 Mar 1973. 9p. Dep. NTIS.

**23999** (DOCKET-50155-140) BIG ROCK POINT NUCLEAR PLANT. Nuclear Quality Assurance Policy Manual. (Consumers Power Co., Jackson, Mich.). 8 Mar 1973. 30p. Dep. NTIS $3.50.

**24000** (DOCKET-50206-185) SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1. Applicants' Environmental Report, Amendment 1. (Southern California Edison Co., Rosemead, Calif; San Diego Gas and Electric Co., Calif.). 21 Feb 1973. 362p. Dep. NTIS.

**24001** (DOCKET-50206-187) SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1. Containment Sphere Atmosphere Radiation Monitoring. (Southern California Edison Co., Rosemead, Calif.). 26 Feb 1973. 2p. Dep. NTIS.

**24002** (DOCKET-50206-188) SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1. Fuel Densification, December 1972, Revision 1, February 1973. (Southern California Edison Co., Rosemead, Calif.). 1 Mar 1973. 40p. Dep. NTIS.

**24003** (DOCKET-50219-238) OYSTER CREEK NUCLEAR POWER PLANT, UNIT 1. Report of Operations, July 1, 1972-December 31, 1972. (Jersey Central Power and Light Co., Morristown, N. J.). 2 Mar 1973. 61p. Dep. NTIS.

**24004** (DOCKET-50219-240) OYSTER CREEK NUCLEAR POWER PLANT, UNIT 1. Application For The Full Term License, Supplement 4. (Jersey Central Power and Light Co., Morristown, N. J.). 5 Mar 1973. 20p. Dep. NTIS $3.00.

**24005** (DOCKET-50220-126) NINE MILE POINT NUCLEAR STATION, UNIT 1. Environmental Report, Supplement 1. (Niagara Mohawk Power Corp., Syracuse, N. Y.). 2 Mar 1973. 46p. Dep. NTIS.

**24006** (DOCKET-50237-297) DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3. Quad-Cities Station, Units 1 and 2. Additional Information on Oxygen Sampling Systems. (Commonwealth Edison Co., Chicago, Ill.). 26 Jan 1973. 2p. (DOCKET-50249-188; DOCKET-50254-161; DOCKET-50265-152). Dep. NTIS.

**24007** (DOCKET-50237-300) DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3. Quad-Cities Station, Units 1 and 2. Proposed Containment Atmospheric Dilution. (Commonwealth Edison Co., Chicago, Ill.). 20 Feb 1973. 41p. (Docket-50249-191; Docket-50254-167; Docket-50265-158). Dep. NTIS.

**24008** (DOCKET-50237-301) DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3. Safety Analysis Report, Proposed Modification 73-1. (Commonwealth Edison Co., Chicago, Ill.). 1 Mar 1973. 7p. (DOCKET-50249-192). Dep. NTIS.

Revisions for the operating quality assurance program are presented. (DCC)

**24009** (DOCKET-50237-302) DRESDEN NUCLEAR POWER STATION, UNIT 3. Safety Analysis Report, Proposed Modification 73-2. (Commonwealth Edison Co., Chicago, Ill.). 5 Mar 1973. 32p. (DOCKET-50249-193). Dep. NTIS.

Information is presented concerning operations with Reload 1 fuel assemblies. (DCC)

**24010** (DOCKET-50237-305) DRESDEN NUCLEAR POWER STATION, UNIT 2. Application for Conversion from Provisional Operating License to a Full Term License. (Commonwealth Edison Co., Morris, Ill. (USA)). Mar 1973. 318p. Dep. NTIS $18.00.

**24011** (DOCKET-50237-306) DRESDEN NUCLEAR POWER STATION, UNIT 2. Environmental Report, Supplement 5. (Commonwealth Edison Co., Chicago, Ill.). 12 Mar 1973. 41p. (DOCKET-50249-195). Dep. NTIS $4.25.

**24012** (DOCKET-50238-97) N. S. SAVANNAH. Action taken with regard to items of noncompliance brought to attention following inspection on March 2-3, 1972. (Maritime Administration, Washington, D. C.). 19 Jul 1972. 6p. Dep. NTIS.

Information is presented concerning administrative procedures and fire alarm system. (DCC)

**24013** (DOCKET-50244-146) ROBERT EMMETT GINNA NUCLEAR POWER PLANT, UNIT 1. Type A Reactor Containment Building Periodic Retest and Type B and C Histories. (Gilbert Associates, Inc., Reading, PA). Mar 1973. 122p. (GAI-1783). Dep. NTIS $8.25.

**24014** (DOCKET-50244-147) ROBERT EMMETT GINNA NUCLEAR POWER PLANT, UNIT 1. Pressurizer Safety Valve Supports. (Rochester Gas and Electric Corp., N. Y.). 15 Mar 1973. 19p. Dep. NTIS $3.00.

**24015** (DOCKET-50244-148) ROBERT EMMETT GINNA NUCLEAR POWER PLANT, UNIT 1. Main Steam Safety Valve Supports. (Rochester Gas and Electric Corp., N. Y.). 15 Mar 1973. 40p. Dep. NTIS $4.00.

**24016** (DOCKET-50245-197) MILLSTONE NUCLEAR POWER STATION, UNIT 1. Personnel Radiation Exposure Control Program. (Millstone Point Co., Hartford, Conn.). 9 Mar 1973. 14p. Dep. NTIS $3.00.

**24017** (DOCKET-50245-198) MILLSTONE NUCLEAR POWER STATION, UNIT 1. Drywell Vacuum Breakers. (Millstone Point Co., Hartford, Conn.). 12 Mar 1973. 5p. Dep. NTIS $3.00.

**24018** (DOCKET-50247-92) INDIAN POINT NUCLEAR GENERATING UNIT 2. Additional Information Concerning the Re-analysis of Safety and Relief Valve Installations. (Consolidated Edison Co. of New York, Inc., New York). 9 Feb 1973. 35p. Dep. NTIS.

**24019** (DOCKET-50250-113) TURKEY POINT PLANT, UNITS 3 AND 4. Limitorque Valve Operators. (Florida Power and Light Co.). 8 Mar 1973. 8p. (DOCKET-50251-94). Dep. NTIS.

**24020** (DOCKET-50250-114) TURKEY POINT PLANT, UNITS 3 AND 4. Fuel Densification. (Florida Power and Light Co.). 5 Mar 1973. 70p. (DOCKET-50251-95; WCAP-8075). Dep. NTIS.

**24021** (DOCKET-50250-115) TURKEY POINT PLANT, UNITS 3 AND 4. Technical specifications, proposed changes. (Florida Power and Light Co.). 16 Mar 1973. 26p. (Docket-50251-96). Dep. NTIS $3.50.

**24022** (DOCKET-50251-97) TURKEY POINT PLANT, UNIT 4. Reactor Containment Building Integrated Leak Rate Test. (Florida Power and Light Co.). 10 Mar 1972. 234p. Dep. NTIS $13.75.

**24023** (DOCKET-50254-166) QUAD-CITIES STATION, UNITS 1 AND 2. Special Report No. 2A, Supplemental Information Concerning Jet Pump Operability. (Commonwealth Edison Co., Chicago, Ill.). 22 Feb 1973. 10p. (DOCKET-50265-157). Dep. NTIS.

**24024** (DOCKET-50254-171) QUAD-CITIES STATION, UNITS 1 AND 2. Safety analysis report, proposed modification

73-1. (Commonwealth Edison Co., Chicago, Ill.). 1 Mar 1973. 7p. (Docket-50265-160). Dep. NTIS.
A requested modification of the quality assurance program for the Quad-Cities Station, Units 1 and 2 is presented. (JWR)

**24025** (DOCKET-50255-141) PALISADES PLANT. Reclassification of System Components and Subsystems. (Consumers Power Co., Jackson, Mich.). 8 Mar 1973. 2p. Dep. NTIS $3.00.
Additional information is presented concerning the radioactive waste systems. (DCC)

**24026** (DOCKET-50259-75) BROWNS FERRY NUCLEAR POWER STATION, UNITS 1, 2, AND 3. Comments on RO Inspection Reports 50-259/72-8, 50-260/72-4, 50-296/72-4. (Tennessee Valley Authority, Chattanooga). 16 Dec 1972. 28p. (DOCKET-50260-71; DOCKET-50296-69). Dep. NTIS.
Additional information is presented concerning fuel element assemblies. (DCC)

**24027** (DOCKET-50259-76) BROWNS FERRY NUCLEAR POWER STATION, UNITS 1, 2, AND 3. Final Safety Analysis Report, Amendment 47. (Tennessee Valley Authority, Chattanooga). 13 Feb 1973. 291p. (DOCKET-50260-72; DOCKET-50296-70). Dep. NTIS.
Revised proposed technical specifications are presented. (DCC)

**24028** (DOCKET-50259-78) BROWNS FERRY NUCLEAR POWER STATION, UNITS 1, 2, AND 3. Final Safety Analysis Report, Amendment 48. (Tennessee Valley Authority, Chattanooga). 5 Mar 1973. 107p. (DOCKET-50260-73; DOCKET-50296-71). Dep. NTIS $7.50.
Revised and additional data are presented concerning the containment system, personnel qualifications, structures, engineered safeguards, radioactive waste systems, and the rod sequence control system. (DCC)

**24029** (DOCKET-50259-79) BROWNS FERRY NUCLEAR POWER STATION, UNITS 1, 2, AND 3. Review of Control Circuits of Safety-Related Equipment. (Tennessee Valley Authority, Chattanooga). 9 Mar 1973. 2p. (DOCKET-50260-74; DOCKET-50296-72). Dep. NTIS $3.00.

**24030** (DOCKET-50259-80) BROWNS FERRY NUCLEAR POWER STATION, UNIT 1. Preoperational Test. (Tennessee Valley Authority, Chattanooga). 9 Feb 1973. 24p. Dep. NTIS $3.25.

**24031** (DOCKET-50261-140) H. B. ROBINSON UNIT 2. Technical Specifications, Changes Requested. (Carolina Power and Light Co., Raleigh, N. C.). 1 Feb 1973. 6p. Dep. NTIS.
Revised technical specifications are presented concerning calibration of instrumentation and operating personnel qualifications. (DCC)

**24032** (DOCKET-50261-148) H. B. ROBINSON UNIT 2. Safety Equipment Control Circuit Design. (Carolina Power and Light Co., Raleigh, N. C.). 27 Feb 1973. 1p. Dep. NTIS.

**24033** (DOCKET-50263-177) MONTICELLO NUCLEAR GENERATING PLANT, UNIT 1. Technical specifications, change request dated January 31, 1973. (Northern States Power Co., Minneapolis, Minn.). 2 Feb 1973. 20p. Dep. NTIS.
Revised technical specifications are presented concerning the emergency core cooling system and the refueling interlock system. (DCC)

**24034** (DOCKET-50263-190) MONTICELLO NUCLEAR GENERATING PLANT, UNIT 1. Rod Drop Accident Analysis. (Northern States Power Co., Minneapolis, Minn.). 2 Mar 1973. 4p. Dep. NTIS $3.00.

**24035** (DOCKET-50263-191) MONTICELLO NUCLEAR GENERATING PLANT, UNIT 1. Report on Torus to Drywell Vacuum Breakers. (Northern States Power Co., Minneapolis, Minn.). 12 Mar 1973. 29. Dep. NTIS $3.50.

**24036** (DOCKET-50266-97) POINT BEACH NUCLEAR PLANT, UNIT 1. Fuel Densification Effect. (Westinghouse Electric Corp., Pittsburgh, PA). Jan 1973. 112p. (WCAP-8051). Dep. NTIS.
For Wisconsin Electric Power Co., Milwaukee.

**24037** (DOCKET-50267-55) FORT ST. VRAIN NUCLEAR GENERATING STATION. Circuit Breakers. Limitorque Valve Operators. (Public Service Co. of Colorado, Denver). 16 Mar 1973. 9p. Dep. NTIS $3.00.

**24038** (DOCKET-50269-93) OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3. Limitorque Valve Operators. (Duke Power Co., Charlotte, N. C.). 8 Mar 1973. 6p. (DOCKET-50270-75; DOCKET-50287-67). Dep. NTIS.

**24039** (DOCKET-50270-77) OCONEE NUCLEAR STATION, UNITS 2 AND 3. Subcompartment Pressure Analysis. (Duke Power Co., Charlotte, N. C.). 2 Mar 1973. 11p. (DOCKET-50287-69). Dep. NTIS $3.00.

**24040** (DOCKET-50271-146) VERMONT YANKEE NUCLEAR POWER STATION. Offsite Environmental Radiological Monitoring, July 1, 1972-December 31, 1972. (Vermont Yankee Nuclear Power Corp., Rutland). 1 Mar 1973. 29p. Dep. NTIS.

**24041** (DOCKET-50271-153) VERMONT YANKEE NUCLEAR POWER STATION. Control Circuit for Safety Related Equipment. (Vermont Yankee Nuclear Power Corp., Rutland). 13 Mar 1973. 4p. Dep. NTIS $3.00.

**24042** (DOCKET-50271-154) VERMONT YANKEE NUCLEAR POWER STATION. Proposed Change 8, Supplement 1, Plant Site Plan Drawing. (Vermont Yankee Nuclear Power Corp., Rutland). 15 Mar 1973. 3p. Dep. NTIS $3.00.

**24043** (DOCKET-50272-49) SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2. Final safety analysis report, Amendment 19. (Public Service Electric and Gas Co., Newark, N.J.). 14 Feb 1973. 87p. (Docket 50311-50). Dep. NTIS.
Revised and requested information is presented concerning personnel qualifications and training requirements. (DCC)

**24044** (DOCKET-50272-50) SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2. Service Water Electrical Duct Run, Omission of Rebars. (Public Service Electric and Gas Co., Newark, N. J.). 7 Mar 1973. 3p. (DOCKET-50311-51). Dep. NTIS $3.00.

**24045** (DOCKET-50272-51) SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2. Final safety analysis report, Amendment 20. (Public Service Electric and Gas Co., Newark, N. J.). 6 Mar 1973. 70p. (Docket 50311-52). Dep. NTIS $5.50.
Requested additional information on the Salem Power Reactor, Units 1 and 2 is presented for the following subjects: site; buildings and equipment; engineered safety features; auxiliary systems; and radioactive waste disposal. (JWR)

**24046** (DOCKET-50272-52) SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2. Damage to Pumps. (Public Service Electric and Gas Co., Newark, N. J.). 7 Mar 1973. 3p. DOCKET-50311-53). Dep. NTIS $3.00.

**24047** (DOCKET-50275-32) DIABLO CANYON NUCLEAR POWER PLANT, UNITS 1 AND 2. Limitorque Valve Operators. (Pacific Gas and Electric Co., San Francisco, Calif.). 8 Mar 1973. 3p. (DOCKET-50323-31). Dep. NTIS $3.00.

**24048** (DOCKET-50277-76) PEACH BOTTOM ATOMIC POWER STATION, UNIT 2. Apparent Misunderstandings of Various Items in Inspection Report No. 50-277/72-11. (Philadelphia Electric Co., PA). 26 Jan 1973. 36p. Dep. NTIS.
Additional information is presented concerning the emergency plan and the shipping procedures for nuclear materials. (DCC)

**24049** (DOCKET-50277-77) PEACH BOTTOM ATOMIC POWER STATION, UNIT 2. Radioactive Effluent Releases. (Philadelphia Electric Co., PA). 2 Mar 1973. 10p. (Docket-50278-74). Dep. NTIS.

**24050** (DOCKET-50280-111) SURRY POWER STATION, UNITS 1 AND 2. Limitorque Valve Operators. (Virginia Electric and Power Co., Richmond). 11 Dec 1972. 7p. (DOCKET-50281-88). Dep. NTIS.

**24051** (DOCKET-50281-90) SURRY POWER STATION, UNIT 2. Fuel Densification Effects, Supplement. (Virginia Electric and Power Co., Richmond). 7 Mar 1973. 5p. Dep. NTIS $3.00.

**24052** (DOCKET-50282-89) PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2. Final Safety Analysis Report, Amendment 28. (Northern States Power Co., Minneapolis, Minn.). 1 Feb 1972. 41p. (DOCKET-50306-85). Dep. NTIS.
Additional information is presented concerning pipe failure outside the containment structure. (DCC)

**24053** (DOCKET–50282–90) PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2. Final Safety Analysis Report, Amendment 29. (Northern States Power Co., Minneapolis, Minn.). 15 Feb 1973. 285p. (DOCKET–50306–86). Dep. NTIS.

Revised and additional data are presented concerning piping systems, structures, and technical specifications. (DCC)

**24054** (DOCKET–50282–91) PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNIT 1. Steps Taken To Correct Items Of Noncompliance Brought To Attention Following Inspection November 15, 16 And 17, 1972. (Northern States Power Co., Minneapolis, Minn.). 26 Jan 1973. 16p. Dep. NTIS.

Additional information is presented concerning the emergency diesel generator overspeed test requirements. (DCC)

**24055** (DOCKET–50282–93) PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2. Final Safety Analysis Report, Amendment 30. (Northern States Power Co., Minneapolis, Minn.). 8 Mar 1973. 23p. (DOCKET–50306–88). Dep. NTIS $3.25.

Additional information is presented concerning containment structure differential pressures during reactor accidents. (DCC)

**24056** (DOCKET–50282–94) PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNIT 1. Final safety analysis report, Amendment 31. (Northern States Power Co., Minneapolis, Minn.). 17 Mar 1973. 190p. (Docket 50306–89). Dep. NTIS $11.50.

Additional information on the high energy fluid piping systems for the Prairie Island Nuclear Generating Plant, Unit 1 is presented. (JWR)

**24057** (DOCKET–50282–95) PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2. Draft Environmental Statement Comments of the Soil Conservation Service and Forest Service. (Department of Agriculture, Washington, D. C.). 21 Mar 1973. 3p. (DOCKET–50306–90). Dep. NTIS $3.00.

**24058** (DOCKET–50282–96) PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2. Safety Evaluation, Supplement 1. (Directorate of Licensing (AEC), Washington, D. C.). 21 Mar 1973. 30p. (DOCKET–50306–91). Dep. NTIS $3.50.

**24059** (DOCKET–50286–66) INDIAN POINT NUCLEAR GENERATING UNIT 3. Final Facility Description and Safety Analysis Report, Supplement 13. (Consolidated Edison Co. of New York, Inc., New York). 2 Mar 1973. 115p. Dep. NTIS.

Revised and requested data are presented concerning emergency plans, personnel qualifications, auxiliary systems, instrumentation, engineered safeguards, electrical systems, and reactor site. (DCC)

**24060** (DOCKET–50286–67) INDIAN POINT NUCLEAR GENERATING UNIT 3. Applicant's Environmental Report, Supplement 5. (Consolidated Edison Co. of New York, Inc., New York). 15 Mar 1973. 11p. Dep. NTIS $3.00.

**24061** (DOCKET–50286–68) INDIAN POINT NUCLEAR GENERATING UNIT 3. Final Facility Description and Safety Analysis Report, Supplement 14. (Consolidated Edison Co. of New York, Inc., New York). 16 Mar 1973. 109p. Dep. NTIS $7.50.

Revised and additional data are presented concerning safety analysis, auxiliary systems, and site meteorology. (DCC)

**24062** (DOCKET–50289–90) THREE MILE ISLAND NUCLEAR STATION, UNIT 1. Action Taken to Correct Noncompliance Item No. 3 and Nonconformance. Item No. 19 Brought to Attention Following Inspection August 14–17, 1972. (Metropolitan Edison Co., Reading, PA). 31 Jan 1973. 3p. (Docket-50320-44). Dep. NTIS.

Information is presented concerning the weld materials and welding procedures used in construction of the reactor piping systems. (DCC)

**24063** (DOCKET–50298–67) COOPER NUCLEAR STATION. Final safety analysis report, Amendment 18. (Nebraska Public Power District, Columbus). 12 Feb 1973. 19p. Dep. NTIS.

Requested additional information on the site, containment system, and radioactive waste systems for the Cooper Nuclear Station is presented. (JWR)

**24064** (DOCKET–50293–106) PILGRIM NUCLEAR POWER STATION. Abnormal Occurrences AO-72-15 and AO-72-16. (Boston Edison Co., Mass.). 4 Dec 1972. 20p. Dep. NTIS.

Information is presented concerning the control circuits for engineered safeguards and incorrect calibration of main steam relief valves. (DCC)

**24065** (DOCKET–50295–85) ZION STATION NUCLEAR POWER PLANT, UNITS 1 AND 2. Final Safety Analysis Report, Amendment 25. (Commonwealth Edison Co., Chicago, Ill.). Jan 1973. 170p. (DOCKET–50304–80). Dep. NTIS.

Revised and additional data are presented concerning the quality assurance program, safety analysis, instrumentation, engineered safeguards thermal recombines, containment structure, technical specifications, and fuel densification. (DCC)

**24066** (DOCKET–50295–88) ZION STATION NUCLEAR POWER PLANT, UNITS 1 AND 2. Final Safety Analysis Report, Amendment 26. (Commonwealth Edison Co., Chicago, Ill.). 14 Mar 1973. 36p. (DOCKET–50304–81). Dep. NTIS $4.00.

Revised and requested information is presented concerning the startup testing program, accident analysis, and containment structure seismic instrumentation. (DCC)

**24067** (DOCKET–50302–61) CRYSTAL RIVER NUCLEAR GENERATING PLANT, UNIT 3. Environmental status report, July–September 1972. (Florida Power and Light Co.). 1972. 143p. Dep. NTIS.

**24068** (DOCKET–50302–63) CRYSTAL RIVER NUCLEAR GENERATING PLANT, UNIT 3. Final safety analysis report, Amendment 24. (Florida Power Corp., St. Petersburg). 28 Feb 1973. 515p. Dep. NTIS.

Revised and requested data are presented concerning the cooling system, physics parameters, engineered safeguards, instrumentation, auxiliary systems, personnel qualifications, emergency plan, testing program, containment structure, and safety analysis. (DCC)

**24069** (DOCKET–50305–72) KEWAUNEE NUCLEAR POWER PLANT. Final safety analysis report, Amendment 25. (Wisconsin Public Service Corp., Green Bay). 31 Jan 1973. 44p. Dep. NTIS.

Revised and requested data are presented concerning piping system breaks. (DCC)

**24070** (DOCKET–50305–73) KEWAUNEE NUCLEAR POWER PLANT. Final Safety Analysis Report, Amendment 26. (Wisconsin Public Service Corp., Green Bay). 5 Feb 1973. 211p. Dep. NTIS.

Technical specifications are presented for reactor operations. (DCC)

**24071** (DOCKET–50305–74) KEWAUNEE NUCLEAR POWER PLANT. Final Safety Analysis Report, Amendment 27. (Wisconsin Public Service Corp., Green Bay). 16 Mar 1973. 129p. Dep. NTIS $8.50.

Requested information is presented concerning containment structure pressures and the failure of piping systems. (DCC)

**24072** (DOCKET–50309–92) MAINE YANKEE ATOMIC POWER STATION. Proposed Interim Special Technical Specifications. (Maine Yankee Atomic Power Co., Westboro, Mass.). 1 Mar 1973. 61p. Dep. NTIS.

**24073** (DOCKET–50309–95) MAINE YANKEE ATOMIC POWER STATION. Semiannual Environmental Surveillance Report, September 15, 1972–December 31, 1972. (Maine Yankee Atomic Power Co., Westboro, Mass.). Feb 1973. 158p. Dep. NTIS $10.00.

**24074** (DOCKET–50309–96) MAINE YANKEE ATOMIC POWER STATION. Documents in Support of Operation at 2440 MWt. (Maine Yankee Atomic Power Co., Westboro, Mass.). 12 Mar 1973. 186p. (CENPD-73(Sup. 2)(Rev. 1); CENPD-75 (Sup. 2)(Rev. 1); CENPD-79(Sup. 1)(Rev. 1)). Dep. NTIS $11.50.

**24075** (DOCKET–50312–62) RANCHO SECO NUCLEAR GENERATING STATION, UNIT 1. Final safety analysis report, Amendment 19. (Sacramento Municipal Utility District, Calif.). 20 Feb 1973. 125p. Dep. NTIS.

Revised and requested data are presented concerning auxiliary systems, emergency systems, instrumentation, containment structure, cooling system, operations aspects, and electrical systems. (DCC)

**24076** (DOCKET–50312–64) RANCHO SECO NUCLEAR GENERATING STATION, UNIT 1. Final safety analysis report, Amendment 20. (Sacramento Municipal Utility District, Calif.). 19 Mar 1973. 106p. Dep. NTIS $7.50.

Revised and requested data on the cooling system, auxiliary systems, radioactive waste disposal system, and accident analysis of the Rancho Seco Station, Unit 1 are presented. (JWR)

**24077** (DOCKET–50313–65) ARKANSAS NUCLEAR ONE, UNIT 1. Final safety analysis report, Amendment 34. (Arkansas Power and Light Co., Little Rock). 9 Feb 1973. 68p. Dep. NTIS.

Revised and requested data are presented concerning safety analysis, instrumentation, personnel qualifications, and engineered safeguards. (DCC)

**24078** (DOCKET-50313-66) ARKANSAS NUCLEAR ONE, UNIT 1. Final Safety Analysis Report, Amendment 35. (Arkansas Power and Light Co., Little Rock). 28 Feb 1973. 12p. Dep. NTIS.

Requested information is presented concerning Limitorque Model SMB valve operators. (DCC)

**24079** (DOCKET-50313-67) ARKANSAS NUCLEAR ONE, UNIT 1. Environmental Monitoring Program. (Arkansas Power and Light Co., Little Rock). 14 Mar 1973. 28p. Dep. NTIS $3.50.

**24080** (DOCKET-50313-68) ARKANSAS NUCLEAR ONE, UNIT 1. Preoperational Test Program. (Arkansas Power and Light Co., Little Rock). 14 Mar 1973. 34p. Dep. NTIS $3.75.

**24081** (DOCKET-50315-95) DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2. Final safety analysis report, Amendment 36. (Indiana and Michigan Power Co., New York). 30 Jan 1973. 83p. (Docket-50316-95). Dep. NTIS.

Revised and requested data on the Donald C. Cook Power Reactor, Units 1 and 2 are presented under the following headings: engineered safeguards; auxiliary systems; containment systems; operations aspects; buildings and structures; radioactive waste disposal systems; instrumentation; electrical systems; and safety analysis. (JWR)

**24082** (DOCKET-50315-98) DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2. Final Safety Analysis Report, Amendment 39. (Westinghouse Electric Corp., Pittsburgh, PA). 12 Mar 1973. 498p. (DOCKET-50316-98). Dep. NTIS $27.00.

For Indiana and Michigan Power Co., New York, NY and Indiana and Michigan Electric Co., New York, NY.

Performance evaluation for the ice condenser containment system is presented. (DCC)

**24083** (DOCKET-50317-81) CALVERT CLIFFS NUCLEAR POWER PLANT, UNITS 1 AND 2. Action Taken With Respect To Quality Assurance Program at Sandvik Steel Works Plant, Sandviken, Sweden. (Baltimore Gas and Electric Co., MD). 10 Jan 1973. 21p. (DOCKET-50318-78). Dep. NTIS.

**24084** (DOCKET-50317-83) CALVERT CLIFFS NUCLEAR POWER PLANT, UNITS 1 and 2. Final safety analysis report, Amendment 33. (Baltimore Gas and Electric Co., Md.). 16 Feb 1973. 112p. (Docket-50318-80). Dep. NTIS.

Revised technical specifications are presented concerning reactor operation. (DCC)

**24085** (DOCKET-50321-68) EDWIN I. HATCH NUCLEAR PLANT, UNIT 1. Final safety analysis report, Amendment 28. (Georgia Power Co., Atlanta). 26 Jan 1973. 222p. Dep. NTIS.

Revised and requested data are presented concerning the emergency plan, auxiliary systems, containment system, testing program, radioactive waste systems, instrumentation, cooling system, physics calculations, quality assurance program, electrical system, and site. (DCC)

**24086** (DOCKET-50323-29) DIABLO CANYON NUCLEAR POWER PLANT, UNIT 2. Reactor Vessel Ultrasonic Indications. (Pacific Gas and Electric Co., San Francisco, Calif.). 28 Feb 1973. 4p. Dep. NTIS.

**24087** (DOCKET-50324-66) BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2. Environmental Report, Amendment 6. (Carolina Power and Light Co., Raleigh, N. C.). 29 Jan 1973. 28p. (DOCKET-50325-67). Dep. NTIS.

Additional information is presented concerning cost-benefit evaluation of power transmission line towers for the Cape Fear River crossing. (DCC)

**24088** (DOCKET-50324-67) BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2. Final safety analysis report, Amendment 15. (Carolina Power and Light Co., Raleigh, N. C.). 5 Mar 1973. 808p. (Docket-50325-68). Dep. NTIS.

Revised and requested data are presented concerning operations aspects, structures, personnel, emergency plan, radioactive waste systems, instrumentation, containment structure, cooling system, piping system, safety analysis, electrical systems, and site. (DCC)

**24089** (DOCKET-50324-68) BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2. (Carolina Power and Light Co., Raleigh, N. C.). 5 Mar 1973. 112p. (DOCKET-50325-69). Dep. NTIS.

Requested data on the plant electrical drawings for the Brunswick Steam Electric Plant, Units 1 and 2 are presented. (JWR)

**24090** (DOCKET-50324-69) BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2. Reactor Pressure Vessel, Jet Pump Adapter Deficiency. (Carolina Power and Light Co., Raleigh, N. C.). 27 Feb 1973. 5p. (DOCKET-50325-70). Dep. NTIS $3.00.

**24091** (DOCKET-50327-33) SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2. Fabrication of Pressure Vessels. (Tennessee Valley Authority, Chattanooga). 20 Mar 1973. 8p. (DOCKET-50328-31). Dep. NTIS $3.00.

**24092** (DOCKET-50331-83) DUANE ARNOLD ENERGY CENTER. Final Safety Analysis Report, Amendment 12. (Iowa Electric Light and Power Co., Cedar Rapids). Feb 1973. 36p. Dep. NTIS.

Revised and requested data are presented concerning piping systems, structures, and instrumentation. (DCC)

**24093** (DOCKET-50331-84) DUANE ARNOLD ENERGY CENTER. Environmental Monitoring Program, July 1, 1972–September 30, 1972. (Eberline Instrument Corp., Santa Fe, N. Mex. Dept. of Nuclear Sciences). 1972. 44p. Dep. NTIS.

**24094** (DOCKET-50333-82) JAMES A. FITZPATRICK NUCLEAR POWER PLANT. Limitorque Valve Operators. 2 Feb 1973. 4p. Dep. NTIS.

**24095** (DOCKET-50333-83) JAMES A. FITZPATRICK NUCLEAR POWER PLANT. Reactor Pedestal Crack. 5 Mar 1973. 12p. Dep. NTIS.

**24096** (DOCKET-50333-84) JAMES A. FITZPATRICK NUCLEAR POWER PLANT. Final Environmental Statement. (Directorate of Licensing (AEC), Washington, D. C.). Mar 1973. 343p. Dep. NTIS $19.25.

The environmental effects of construction and operation of the James A. Fitzpatrick Power Reactor are examined. The descriptions include: (1) the environment in the area, including the history, geography, and geology, hydrology, climatology, ecology, land and water use including chemical characteristics, (2) the facility and its effluents, (3) the impacts from construction and operation of the unit, (4) alternatives to the proposed action, (5) irreversible and irretrievable long-term commitments of resources from plant operation, (6) need for power, and (7) the benefits-cost analysis of the proposed plant operation. (JWR)

**24097** (DOCKET-50334-54) BEAVER VALLEY POWER STATION, UNIT 1. Action Taken to Correct Items of Noncompliance Brought to Attention Following Inspection November 28–December 1, 1972. (Duquesne Light Co., Pittsburgh, PA). 8 Jan 1973. 18p. Dep. NTIS.

Information is presented concerning the installation of stainless steel piping systems and spent fuel pool lines. (DCC)

**24098** (DOCKET-50334-56) BEAVER VALLEY POWER STATION, UNIT 1. Draft Environmental Statement. (Directorate of Licensing (AEC), Washington, D. C.). Mar 1973. 174p. Dep. NTIS $10.75.

The environmental effects of construction and operation of the Beaver Valley Power Reactor, Unit 1 are examined. The descriptions include: (1) the environment in the area, including the history, geography and geology, hydrology, climatology, ecology, land and water use including chemical characteristics, (2) the facility and its effluents, (3) the impacts from construction and operation of the unit, (4) alternatives to the proposed action, (5) irreversible and irretrievable long-term commitments of resources from plant operation, (6) need for power, and (7) the benefits-cost analysis of the proposed plant operation. (JWR)

**24099** (DOCKET-50335-44) ST. LUCIE PLANT, UNIT 1. Final Safety Analysis Report. Volume 1. (Florida Power and Light Co.). 28 Feb 1973. 449p. Dep. NTIS.

Information on the site for the St. Lucie Power Reactor, Unit 1 is presented. (JWR)

**24100** (DOCKET-50335-45) ST. LUCIE PLANT, UNIT 1. Final Safety Analysis Report, Volume 2. (Florida Power and Light Co.). 1973. 394p. Dep. NTIS.

Information on design criteria for the structures, components, equipment, and systems for the St. Lucie Power Reactor, Unit 1 is presented. (JWR)

**24101** (DOCKET-50335-46) ST. LUCIE PLANT, UNIT 1. Final Safety Analysis Report, Volume 3. (Florida Power and Light Co.). 1973. 376p. Dep. NTIS.
Information on the mechanical, nuclear, and thermal and hydraulic design and on the cooling system for the St. Lucie Power Reactor, Unit 1 is presented. (JWR)

**24102** (DOCKET-50335-47) ST. LUCIE PLANT, UNIT 1. Final Safety Analysis Report, Volume 4. (Florida Power and Light Co.). 1971. 456p. Dep. NTIS.
Information on the engineered safety features, instrumentation, and control system for the St. Lucie Power Reactor, Unit 1 is presented. (JWR)

**24103** (DOCKET-50335-48) ST. LUCIE PLANT, UNIT 1. Final Safety Analysis Report, Volume 5. (Florida Power and Light Co.). 1973. 303p. Dep. NTIS.
Information on the electrical system and the auxiliary systems for the St. Lucie Power Reactor, Unit 1 is presented. (JWR)

**24104** (DOCKET-50335-49) ST. LUCIE PLANT, UNIT 1. Final Safety Analysis Report, Volume 6. (Florida Power and Light Co.). 1973. 244p. Dep. NTIS.
Information on the steam and power conversion system, radioactive waste management, and radiation protection at the St. Lucie Power Reactor, Unit 1 is presented. (JWR)

**24105** (DOCKET-50335-50) ST. LUCIE PLANT, UNIT 1. Final Safety Analysis Report, Volume 7. (Florida Power and Light Co.). 1973. 333p. Dep. NTIS.
Information on the conduct of operations, initial tests and operations, and accident analyses for the St. Lucie Power Reactor, Unit 1 is presented. (JWR)

**24106** (DOCKET-50335-51) ST. LUCIE PLANT, UNIT 1. Final Safety Analysis Report, Volume 8. (Florida Power and Light Co). 1971. 190p. Dep. NTIS.
Information on the St. Lucie Power Reactor Unit 1 is presented concerning technical specifications and quality assurance program. (DCC)

**24107** (DOCKET-50335-52) ST. LUCIE PLANT, UNIT 1. Notice of Receipt of Application for Facility Operating License; Notice of Consideration of Issuance of Facility License and Notice of Opportunity for Hearing. (Florida Power and Light Co.). 20 Mar 1973. 7p. Dep. NTIS $3.00.

**24108** (DOCKET-50336-51) MILLSTONE NUCLEAR POWER STATION, UNIT 2. Final safety analysis report, Amendment 15. (Millstone Point Co., Hartford, Conn.). 16 Feb 1973. 1082p. Dep. NTIS.
Revised and requested data are presented concerning operations aspects, safety analysis, emergency plan, personnel, auxiliary systems, electrical systems, engineered safeguards, containment structure, testing program, instrumentation, and site. (DCC)

**24109** (DOCKET-50338-56) NORTH ANNA POWER STATION, UNIT 1. Results of Inspection of Rotterdam Dockyard Company and Sulzer Brothers, Ltd. (Virginia Electric and Power Co., Richmond). 17 May 1972. 13p. Dep. NTIS.
Additional information is presented concerning procedures for the fabrication of the pressure vessel. (DCC)

**24110** (DOCKET-50338-57) NORTH ANNA POWER STATION, UNITS 1 AND 2. Limitorque Valve Operators. (Virginia Electric and Power Co., Richmond). 8 Mar 1973. 7p. (DOCKET-50339-54). Dep. NTIS.

**24111** (DOCKET-50344-43) TROJAN NUCLEAR PLANT. Final Safety Analysis Report, Volume 6. (Portland General Electric Co., Oreg.). 5 Feb 1973. 625p. Dep. NTIS.
Information on the electrical power system and the auxiliary systems for the Trojan Power Reactor is presented. (JWR)

**24112** (DOCKET-50344-48) TROJAN NUCLEAR PLANT. Application for an Operating License, Amendment 1. (Portland General Electric Co., Oreg.). 9 Mar 1973. 2p. Dep. NTIS $3.00.

**24113** (DOCKET-50344-49) TROJAN NUCLEAR PLANT. Steps Taken to Correct Items Brought to Attention Following Inspection of November 1-3, 1972. (Directorate of Regulatory Operations (AEC), Berkeley, Calif. (USA). Region V). 12 Mar 1973. 13p. Dep. NTIS $3.00.
Additional information is presented concerning quality assurance requirements for construction. (DCC)

**24114** (DOCKET-50344-50) TROJAN NUCLEAR PLANT. Steps Taken to Correct Items Brought to Attention Following Inspection November 28-December 1, 1972. (Directorate of Regulatory Operations (AEC), Berkeley, Calif. (USA). Region V). 13 Mar 1973. 24p. Dep. NTIS $3.25.
Additional information is presented concerning the quality assurance program for construction. (DCC)

**24115** (DOCKET-50344-51) TROJAN NUCLEAR PLANT. Final safety analysis report, Amendment 1. 9 Mar 1973. 688p. Dep. NTIS $36.50.
Revised and requested data are presented concerning radioactive waste systems, steam turbine, auxiliary systems, structures, containment system, instrumentation, radiation protection system, operations aspects, accident analysis, and technical specifications. (DCC)

**24116** (DOCKET-50346-39) DAVIS-BESSE NUCLEAR POWER STATION. Comments on draft environmental impact statement. (Ohio State Environmental Protection Agency, Columbus (USA)). 16 Jan 1973. 6p. Dep. NTIS.

**24117** (DOCKET-50346-40) DAVIS-BESSE NUCLEAR POWER STATION. Review of Non-Class I (seismic) Equipment that Might Potentially Adversely Affect the Performance of Safety-Related Equipment. (Toledo Edison Co., Ohio). 26 Jan 1973. 1p. Dep. NTIS.

**24118** (DOCKET-50346-42) DAVIS-BESSE NUCLEAR POWER STATION. Limitorque Valve Operators. (Toledo Edison Co., Ohio). 7 Feb 1973. 1p. Dep. NTIS $3.00.

**24119** (DOCKET-50348-51) JOSEPH M. FARLEY NUCLEAR PLANT, UNITS 1 AND 2. Evaluation of December 11, 1972 Supplement to Preliminary Safety Analysis Report. (Directorate of Licensing (AEC), Washington, D. C.). 1 Mar 1973. 3p. (Docket-50364-43). Dep. NTIS.
Information is presented concerning the service water system storage pond spillway. (DCC)

**24120** (DOCKET-50358-45) WILLIAM H. ZIMMER NUCLEAR POWER STATION, UNIT 1. Limitorque Valve Operators. (Cincinnati Gas and Electric Co., Ohio). 23 Feb 1973. 5p. Dep. NTIS.

**24121** (DOCKET-50361-36) SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3. Steps taken to correct items brought to attention following inspection October 2-6, 1972. (Southern California Edison Co., Rosemead, Calif.). 8 Feb 1973. 35p. (Docket-50362-35). Dep. NTIS.
Information is presented concerning the quality assurance program for construction activities. (DCC)

**24122** (DOCKET-50363-46) FORKED RIVER NUCLEAR GENERATING STATION, UNIT 1. List of Changed PSAR Pages. (Jersey Central Power and Light Co., Morristown, N. J.). 5 Feb 1973. 42p. Dep. NTIS.

**24123** (DOCKET-50367-35) BAILLY GENERATING STATION, NUCLEAR I. Limitorque Valve Operators. (Northern Indiana Public Service Co., Hammond). 8 Mar 1973. 1p. Dep. NTIS $3.00.

**24124** (DOCKET-50369-36) MCQUIRE NUCLEAR STATION, UNITS 1 AND 2. Issuance of Construction Permits CPPR-83 and CPPR-84. (Directorate of Licensing (AEC), Washington, D. C.). 28 Feb 1973. 11p. (DOCKET-50370-36). Dep. NTIS.

**24125** (DOCKET-50382-50) WATERFORD STEAM ELECTRIC STATION, UNIT 3. Preliminary safety analysis report, Amendment 29. (Louisiana Power and Light Co., New Orleans). 1 Feb 1973. 79p. Dep. NTIS.
Revised and requested data are presented concerning the reactor site, auxiliary systems, emergency systems, and the containment system. (DCC)

**24126** (DOCKET-50382-52) WATERFORD STEAM ELECTRIC STATION, UNIT 3. Preliminary Safety Analysis Report, Amendment 31. (Louisiana Power and Light Co., New Orleans). 5 Mar 1973. 13p. Dep. NTIS.
Revised and requested data are presented concerning instrumentation, engineered safeguards, layout of structures, and auxiliary systems. (DCC)

**24127** (DOCKET-50382-53) WATERFORD STEAM ELECTRIC STATION, UNIT 3. Preliminary safety analysis report, clarification of information previously submitted. (Louisiana Power and Light Co., New Orleans). 15 Mar 1973. 3p. Dep. NTIS $3.00.

A clarification of information on extended soils and foundation studies at the site for the Waterford Steam Electric Station, Unit 3 is presented. (JWR)

**24128** (DOCKET-50387-29) SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2. Safety evaluation, Supplement 1, Errata. (Directorate Of Licensing (AEC), Washington, D.C.). 23 Feb 1973. 7p. (DOCKET-50388—28). Dep. NTIS.

**24129** (DOCKET-50387-30) SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2. Draft Environmental Statement, Comments from Soil Conservation Service and Forest Service. (Department of Agriculture, Washington, D. C.). 26 Mar 1973. 5p. (DOCKET-50388-29). Dep. NTIS $3.00.

**24130** (DOCKET-50390-35) WATTS BAR NUCLEAR PLANT, UNITS 1 AND 2. Preliminary Safety Analysis Report, Amendment 21. (Tennessee Valley Authority, Chattanooga). 13 Feb 1973. 11p. (DOCKET-50391-35). Dep. NTIS.

Additional information is presented concerning stress levels and potential breaks in piping systems. (DCC)

**24131** (DOCKET-50395-41) VIRGIL C. SUMMER NUCLEAR STATION, UNIT 1. Construction Permit CPPR-94 and Federal Register Notice. (South Carolina Electric and Gas Co., Columbia). 26 Mar 1973. 7p. Dep. NTIS $3.00.

**24132** (DOCKET-50397-38) HANFORD NO. 2 NUCLEAR POWER PLANT. Construction Permit No. CPPR-93. (Directorate Of Licensing (AEC), Washington, D. C.). 19 Mar 1973. 6p. Dep. NTIS $3.00.

**24133** (DOCKET-50400-34) SHEARON HARRIS NUCLEAR POWER PLANT, UNITS 1, 2, 3, AND 4. Preliminary safety analysis report, Amendment 21. (Carolina Power and Light Co., Raleigh, N. C.). 2 Feb 1973. 122p. (Docket-50401-34; Docket-50402-34; Docket-50403-33). Dep. NTIS.

Revised and additional data are presented concerning the containment structure, electrical systems, auxiliary systems, safety analysis, and soil characteristics for the reactor site. (DCC)

**24134** (DOCKET-50400-35) SHEARON HARRIS NUCLEAR POWER PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Amendment 22. (Carolina Power and Light Co., Raleigh, N. C.). 28 Feb 1973. 350p. (DOCKET-50401-35; DOCKET-50402-35; DOCKET-50403-35). Dep. NTIS.

Revised and additional data are presented concerning instrumentation, containment structure, and soil characteristics for the reactor site. (DCC)

**24135** (DOCKET-50400-36) SHEARON HARRIS NUCLEAR POWER PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Amendment 23. (Carolina Power and Light Co., Raleigh, N. C.). 15 Mar 1973. 415p. (DOCKET-50401-36; DOCKET-50402-36; DOCKET-50403-36). Dep. NTIS $22.75.

Requested data on the site, containment system, auxiliary systems, and accident analyses for the Shearon Harris Power Reactors, Units 1, 2, 3, and 4 are presented. (JWR)

**24136** (DOCKET-50404-40) NORTH ANNA POWER STATION, UNITS 3 AND 4. Revised PSAR Figures 9.4-1, 9.4-2, 9.4-3, 9.9-1, 6.1-1, and 6.3.1-1. (Virginia Electric and Power Co., Richmond). 16 Feb 1973. 7p. (DOCKET-50405-40). Dep. NTIS.

Flow diagrams are presented for auxiliary and emergency systems. (DCC)

**24137** (DOCKET-50404-41) NORTH ANNA POWER STATION, UNITS 3 AND 4. Effect of Loss of Component Cooling Water. (Virginia Electric and Power Co., Richmond). 7 Mar 1973. 4p. (Docket-50405-41). Dep. NTIS.

**24138** (DOCKET-50404-42) NORTH ANNA POWER STATION, UNITS 3 AND 4. Design of Ventilation Systems and Radioiodine Releases in General. (Virginia Electric and Power Co., Richmond). 7 Mar 1973. 10p. (DOCKET-50405-42). Dep. NTIS.

**24139** (DOCKET-50409-35) LA CROSSE BOILING WATER REACTOR. Technical Evaluation of Flooding of Critical Equipment. (Dairyland Power Cooperative, La Crosse, Wis.). 29 Jan 1973. AT(11-1)-1756. 60p. Dep. NTIS.

**24140** (DOCKET-50409-39) LA CROSSE BOILING WATER REACTOR. Review of Safety Equipment Control Circuits. (Dairyland Power Cooperative, La Crosse, Wis.). 5 Mar 1973. 1p. Dep. NTIS $3.00.

**24141** (DOCKET-50410-21) NINE MILE POINT NUCLEAR STATION, UNIT 2. Preliminary Safety Analysis Report, Supplement 6. (Niagara Mohawk Power Corp., Syracuse, N. Y.). 29 Jan 1973. 434p. Dep. NTIS.

Revised and requested data on the following subjects is presented: quality assurance program; site; reactor physics; cooling system; containment system; engineered safeguards; instrumentation; control system; electrical system: emergency systems; power conversion systems; radioactive waste disposal; and safety analysis. (JWR)

**24142** (DOCKET-50410-22) NINE MILE POINT NUCLEAR STATION, UNIT 2. Preliminary safety analysis report, Supplement 7. (Niagara Mohawk Power Corp., Syracuse, N. Y.). 13 Feb 1973. 20p. Dep. NTIS.

Additional information is presented concerning the safety analysis of a main steam line break. (DCC)

**24143** (DOCKET-50412-5) BEAVER VALLEY POWER STATION, UNIT 2. Preliminary safety analysis report, Amendment 2. (Duquesne Light Co., Pittsburgh, Pa.). 27 Feb 1973. 623p. Dep. NTIS.

Revised and requested data are presented concerning auxiliary systems, engineered safeguards, safety analysis, containment system, radioactive waste systems, power conversion system, instrumentation, cooling system, site, structures, quality assurance program, personnel, and operations aspects. (DCC)

**24144** (DOCKET-50413-9) CATAWBA NUCLEAR STATION, UNITS 1 AND 2. Preliminary safety analysis report, Amendment 3. (Duke Power Co., Charlotte, N. C.). 2 Feb 1973. 84p. (Docket-50414-9). Dep. NTIS.

Revised and requested data are presented concerning personnel, emergency plan, radioactive wastes, containment system, and cooling system. (DCC)

**24145** (DOCKET-50413-11) CATAWBA NUCLEAR STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Amendment 4. (Duke Power Co., Charlotte, N. C.). Mar 1973. 495p. (DOCKET-50414-11). Dep. NTIS. $26.75.

Revised and requested data are presented concerning the quality assurance program, containment structure, site, operations aspects, radioactive waste systems, auxiliary systems, electrical systems, engineered safeguards, and piping systems. (DCC)

**24146** (DOCKET-50416-17) GRAND GULF NUCLEAR STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Amendment 3. (Mississippi Power and Light Co., Jackson (USA)). 19 Mar 1973. 293p. (DOCKET-50417-17). Dep. NTIS $16.75.

Revised and additional data are presented concerning operations aspects, auxiliary systems, electrical systems, instrumentation, engineered safeguards, and structures. (DCC)

**24147** (DOCKET-50423-2) MILLSTONE NUCLEAR POWER STATION, UNIT 3. General and Financial Information. (Millstone Point Co., Hartford, Conn.). Feb 1973. 622p. Dep. NTIS.

**24148** (DOCKET-50424-1) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. License application. (Georgia Power Co., Atlanta). 8 Feb 1973. 79p. (Docket-50425-1; Docket-50426-1; Docket-50427-1). Dep. NTIS.

The application for construction permit and operating license is presented. The 1971 Annual Reports of the Georgia Power Company and The Southern Company are included. (DCC)

**24149** (DOCKET-50424-2) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Environmental Report, Volume 1. (Georgia Power Co., Atlanta). 1 Aug 1972. 338p. (DOCKET-50425-2; DOCKET-50426-2; DOCKET-50427-2). Dep. NTIS.

The environmental effects of the construction and operation of the Alvin W. Vogtle Power Reactors, Units 1, 2, 3, and 4, are examined. Descriptions in Volume 1 include: (1) the proposed plant and site, (2) the need for power, (3) the primary objectives of the plant, (4) the consequences of delay, and (5) the environment in the area including human activities, historic significance, geology and seismology, hydrology, meteorology, biota, and other features. (JWR)

**24150** (DOCKET-50424-3) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Environmental Report, Volume 2. (Georgia Power Co., Atlanta). 1 Aug 1972. 523p. (DOCKET-50425-3; DOCKET-50426-3; DOCKET-50427-3). Dep. NTIS.

The environmental effects of construction and operation of the Alvin W. Vogtle Power Reactor, Units 1, 2, 3, and 4 are examined. The descriptions in Volume 2 include: (1) the plant and its effluents, (2) environmental effects of site preparation and plant construction, (3) environmental effects of plant operation, (4) environmental effects of accidents, (5) unavoidable adverse effects of plant construction and operation, (6) alternatives to construction and operation of the plant, (7) long term effects of plant construction and operation, (8) resources committed in plant construction and operation, and (9) costs and benefits of the plant and alternatives. (JWR)

**24151** (DOCKET-50424-4) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Volume 1. (Georgia Power Co., Atlanta). 8 Feb 1973. 390p. (DOCKET-50425-4; DOCKET-50426-4; DOCKET-50427-4). Dep. NTIS.

A general description of the plant and the characteristics of the site for the Alvin W. Vogtle Power Reactor, Units 1, 2, 3, and 4, is presented. (JWR)

**24152** (DOCKET-50424-5) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Volume 2. (Georgia Power Co., Atlanta). 8 Feb 1973. 557p. (DOCKET-50425-5; DOCKET-50426-5; DOCKET-50427-5). Dep. NTIS.

Information on the geology at the site for the Alvin W. Vogtle Power Reactor, Units 1, 2, 3, and 4 is presented. (JWR)

**24153** (DOCKET-50424-6) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Volume 3. (Georgia Power Co., Atlanta). 8 Feb 1973. 550p. (DOCKET-50425-6; DOCKET-50426-6; DOCKET-50427-6). Dep. NTIS.

Information on the geology and seismology at the site of the Alvin W. Vogtle Power Reactor, Units 1, 2, 3, and 4 is presented. (JWR)

**24154** (DOCKET-50424-7) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Volume 4. (Georgia Power Co., Atlanta). 8 Feb 1973. 569p. (DOCKET-50425-7; DOCKET-50426-7; DOCKET-50427-7). Dep. NTIS.

Information on the subsurface and foundations at the Alvin W. Vogtle Power reactor, Units 1, 2, 3, and 4 is presented. (JWR)

**24155** (DOCKET-50424-8) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Volume 5. (Georgia Power Co., Atlanta). 8 Feb 1973. 552p. (DOCKET-50425-8; DOCKET-50426-8; DOCKET-50427-8). Dep. NTIS.

Information on the design criteria for the structure, components, and systems for the Alvin W. Vogtle Power Reactor, Units 1, 2, 3, and 4 is presented. (JWR)

**24156** (DOCKET-50424-9) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Volume 6. (Georgia Power Co., Atlanta). 8 Feb 1973. 492p. (DOCKET-50425-9; DOCKET-50426-9; DOCKET-50427-9). Dep. NTIS.

Information on the design criteria, reactor cooling system, and engineered safety features for the Alvin W. Vogtle Power Reactor, Units 1, 2, 3, and 4 is presented. (JWR)

**24157** (DOCKET-50424-10) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Volume 7. (Georgia Power Co., Atlanta). 8 Feb 1973. 520p. (DOCKET-50425-10; DOCKET-50426-10; DOCKET-50427-10). Dep. NTIS.

Information on the Alvin W. Vogtle Power Reactor, Units 1, 2, 3, and 4 is presented under the following main headings: instrumentation and controls; electric power; auxiliary systems; steam and power conversion system; radioactive waste management; radiation protection; and conduct of operations. (JWR)

**24158** (DOCKET-50424-11) ALVIN W. VOGTLE NUCLEAR PLANT, UNITS 1, 2, 3, AND 4. Preliminary Safety Analysis Report, Volume 8. (Georgia Power Co., Atlanta). 8 Feb 1973. 406p. (DOCKET-50425-11; DOCKET-50426-11; DOCKET-50427-11). Dep. NTIS.

Information on the initial tests and operation, accident analysis, technical specifications, and quality assurance for the Alvin W. Vogtle Power Reactor, Units 1, 2, 3, and 4 is presented. (JWR)

**24159** (FIND-50400(2-73)) FIND: SHEARON HARRIS NUCLEAR POWER PLANT, UNITS 1, 2, 3, AND 4. Revision 1. Gamble, R. L. (ed.). (Technical Information Center (AEC), Oak Ridge, Tenn.). 20 Feb 1973. 32p. (Find-50401(2-73); Find-50402(2-73); Find-50403(2-73)). Dep. NTIS.

An index to microfiche issuances of safety analysis reports is provided. Subject citations are to specific frames on the microfiche. (FS)

**24160** (HASL-271) ENVIRONMENTAL GAMMA RADIATION FROM $^{16}$N DECAY IN THE TURBINES OF A LARGE BOILING WATER REACTOR. Lowder, W. M.; Raft, P. D.; Gogolak, C. V. (Health and Safety Lab. (AEC), New York). Jan 1973. 15p. Dep. NTIS.

The results of measurements of $^{16}$N radiation in the vicinity of a large boiling water reactor (BWR) are reported as a function of reactor power and distance from the high pressure turbine. This experimental program was designed to develop techniques to distinguish the $^{16}$N radiation from the other components of the environmental gamma radiation field and to determine the free air exposure rate contribution from this source; relate the measured $^{16}$N radiation levels to plant and site parameters; and interpret the data in terms of parameters appropriate for generalization to other reactor sites. The measuring equipment and methods are described. The development of a mathematical model for interpreting the field data and for solving the field exposure rate at various distances and reactor power levels is discussed. It is concluded that: the air exposure rate from the $^{16}$N gamma radiation field can be measured to about ±25% accuracy; the measured exposure rate at a particular location can be scaled to other reactor power levels using the mathematical model, but scaling for distance is highly dubious due to the complexities of the source and field geometry; and this experiment has developed appropriate techniques of measurements but methods for predicting field exposure rate must be refined. (LCL)

**24161** (RAI-73-1) REGULATORY ADJUDICATION ISSUANCES, JANUARY 1973. (Technical Information Center (AEC), Oak Ridge, Tenn.). 15 Feb 1973. 44p. TIC $1.25.

Issuances received from the U. S. Atomic Energy Commission, the Atomic Safety and Licensing Appeal Boards, and the Atomic Safety and Licensing Boards are presented. (JWR)

**24162** (RAI-73-2) REGULATORY ADJUDICATION ISSUANCES, FEBRUARY 1973. (Technical Information Center (AEC), Oak Ridge, Tenn.). 15 Mar 1973. 129p. TIC $1.25.

Issuances received from the U. S. Atomic Energy Commission, the Atomic Safety and Licensing Appeal Boards, and the Atomic Safety and Licensing Boards are presented. (FS)

**24163** (TID-26269) STANDARD FORMAT AND CONTENT OF SAFETY ANALYSIS REPORTS FOR NUCLEAR POWER PLANTS. (Revision 1). (Atomic Energy Commission, Washington, D. C.). Oct 1972. 237p. Dep. NTIS.

**24164** (TID-26270) DRAFT ENVIRONMENTAL STATEMENT CONCERNING PROPOSED RULEMAKING ACTION: ACCEPTANCE CRITERIA FOR EMERGENCY CORE COOLING SYSTEMS FOR LIGHT WATER-COOLED NUCLEAR POWER REACTORS. (Atomic Energy Commission, Washington, D.C.). Dec 1972. 126p. Dep. NTIS.

This action would provide general criteria and evaluation models that will be used by the AEC to evaluate the design of proposed emergency core cooling systems (ECCS) for light-water power reactors with regard to the ability of this system to control the consequences of loss-of-coolant accidents over the entire spectrum of postulated accident conditions. The expected result of this action is to improve assurance of the effective performance of an engineered safety system whose purpose it is to control an accident which has a low probability of occurrence. There are no significant adverse environmental effects associated with the proposed action. (auth)

**24165** (UCLA-ENG-7251) MODELING OF THE SAN ONOFRE NUCLEAR GENERATING STATION FOR SEISMIC RESPONSE. Vasudevan, R.; Ibanez, P.; Shanman, R. D.; Matthiesen, R. B.; Smith, C. B. (California Univ., Los Angeles. School of Engineering and Applied Science). Jul 1972. 114p.

A series of forced vibration tests were conducted and the recorded earthquake response of the San Onofre Nuclear Generating Station (SONGS) was evaluated in order to determine the dynamic structural properties of the containment structure and the primary coolant loop and to develop a mathematical model for predicting the response of the structural system to earthquake inputs. SONGS and its instrumentation are described. An analytical model for the primary coolant loop was developed.

Models of the SONGS containment structure and primary coolant loop, as identified from forced vibration tests, are presented. Finally, all information (forced vibration tests, theory, and measured seismic response) is combined to propose a best model for the prediction of the earthquake response of SONGS. The predicted response of these modified models is then compared to the response actually measured during two earthquakes. (LCL)

## Propulsion and Auxiliary Power Reactors

**24166** (AI-AEC-13056) SNAP AEROSPACE NUCLEAR SAFETY PROGRAM REPORTS: BIBLIOGRAPHY. (Atomics International, Canoga Park, Calif.). 9 Mar 1973. Contract AT(04-3)-701. 33p. Dep. NTIS.

**24167** (RCN-182) COST STUDY ON NUCLEAR PROPULSION FOR CONTAINERSHIPS. van den Bergh, J. W. H.; Bodewes, T. J. J.; Feliks, W. A.; Hurkmans, H. A. E.; Muysken, M.; Weller, P. J. (Reactor Centrum Nederland, Petten). Dec 1972. 42p. Dep. NTIS (U. S. Sales Only) $4.25.

The investment costs and running costs for a series of five conventional and nuclear containerships carrying just over 1,000 containers of 35 ft length with a service speed of 30 knots are estimated and compared. In the nuclear ship the propulsion plant consists of a loop type PWR for 330 MW(t). The net present value method is used for the cost comparison. The nuclear ship shows the same outcome as the conventional ship for bunker fuel prices in the range of about Dfl. 75,-- to Dfl. 110,-- per tonne, depending on rate of interest, depreciation time, sailing schedule, estimated cost for nuclear fuel and possible subsidy in the cost of financing during construction of the nuclear ship. (auth)

## Process Heat and Desalination Reactors

**24168** (STI/DOC-10/140) NUCLEAR ENERGY CENTRES AND AGRO-INDUSTRIAL COMPLEXES. Delyannis, A. A. (International Atomic Energy Agency, Vienna (Austria)). Dec 1972. 145p. IAEA $5.00.

Information is presented to help in understanding the status and potential of agro-industrial complexes in arid lands using desalted sea water. Nuclear-powered agro-industrial complexes consisting of a large nuclear power station could produce electricity and desalted water. The electricity could be consumed in industrial processes and water pumping, while the desalted water could be used for municipal and industrial purposes and in an irrigated agricultural project. Industries producing fertilizers, marine chemicals, caustic soda, chlorine, aluminum, and magnesium are discussed. The ORNL, Puerto Rico, and Indian studies on agro-industrial complexes are reviewed. (FS)

## Research and Test Reactors

*Refer also to abstracts 22525, 22529, 22608, 23015, 23512, 23906, and 23916.*

**24169** (AE-467) IRRADIATION FACILITIES FOR COATED PARTICLE FUEL TESTING IN THE STUDSVIK R2 REACTOR. Sandklef, S. (Aktiebolaget Atomenergi, Studsvik (Sweden)). Jan 1973. 29p. Dep. NTIS (U. S. Sales Only).

Irradiation testing of HTR fuel has been performed in the Studsvik R2 reactor for nearly ten years. During this time there has been continuous development of irradiation devices and out-of-pile equipment. The objectives of coated particle fuel testing are discussed and the important parts of the associated equipment such as irradiation devices, sweep gas circuits, and analyzing equipment are described. Some typical results of release factor measurements are given and the data acquisition system is briefly described. (10 drawings, 2 tables and 5 photographs) (auth)

**24170** (DOCKET-50360-1) PLUTONIUM RECYCLE CRITICAL FACILITY. Annual Operating Report, November 29, 1971–December 31, 1972. (Battelle Pacific Northwest Labs., Richland, Wash.). 26 Feb 1973. 8p. Dep. NTIS $3.00.

**24171** (HEDL-SA-399) THEORETICAL ANALYSIS OF SODIUM REMOVAL FROM FAST FLUX TEST FACILITY FUEL SUBASSEMBLIES. Borisch, R. R. (Hanford Engineering Development Lab., Richland, Wash.). 31 May 1972. 12p. (CONF-721065-1). Dep. NTIS.

From American Society for Testing Materials; Cleveland, OH (17 Oct 1972).

The argon–moist argon–water rinse process is the one method of removing sodium from FFTF test assemblies which will meet all the imposed requirements. Calculations necessary for sizing argon blowers and water rinse tanks are presented. The ability to maintain cooling at all times greatly increases the sodium removal difficulties. However, it is possible to perform all stages of the cleaning process without overheating a subassembly. (auth)

**24172** (HEDL-TME-72-152) FEASIBILITY STUDY ON IN-SERVICE INSPECTION OF SODIUM-CONTAMINATED IHX TUBING WITH SINGLE FREQUENCY EDDY CURRENT NDT EQUIPMENT. Brown, R. L.; Wandling, C. R. (Hanford Engineering Development Lab., Richland, Wash.). 1 Dec 1972. Contract AT(45-1)-2170. 33p. Dep. NTIS $4.00.

A feasibility study was conducted to determine if single frequency eddy current nondestructive testing (NDT) equipment could be used for in-service inspection of sodium-contaminated stainless steel heat exchanger tubing. It was found that the presence of metallic sodium interferes with the detection of holes and notches in the tubing. Some of the difficulties were reduced by allowing the sodium to oxidize in air; however, a more thorough cleaning was required before the interference, due to sodium, could be completely removed. (auth)

**24173** (IRI-131-72-1) INSTALLATION OF A STAINLESS STEEL LINING IN THE HOR-SWIMMING POOL REACTOR. Rijks, H. J. (Interuniversitair Reactor Instituut, Delft (Netherlands)). Aug 1972. 39p. Dep. NTIS (U. S. Sales Only).

The 2 MW pool-type Hoger Onderwijs Reactor (HOR), located at the Interuniversitair Reactor Instituut, Delft, the Netherlands, has had pool leakage problems which date from the initial construction in 1963. The leak rate has slowly increased over the years. When, due to the reactor program, large temperature changes occurred in the cooling water, the leakage rate would increase rapidly. In 1969 it was decided to install a stainless steel pool lining. After a careful review of the literature and subsequent visits to several pool type reactors in Europe, the design principles and technical specifications were formulated. In 1971 the leakage problem was solved by the installation of a stainless steel pool lining in both pools. (auth)

**24174** (KFK–1693) INVESTIGATIONS OF THE EIGENFREQUENCIES AND THE CORRESPONDING VIBRATION MODES OF THE FREE VIBRATION OF FUEL ELEMENT PLATES OF THE GRENOBLE HIGH FLUX REACTOR. Kadlec, J.; Krueger, W. (Kernforschungzentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). Oct 1972. 53p. (In German). Dep. NTIS (U. S. Sales Only).

The measuring equipment is described. The results of investigations covering the first 6 vibration modes are represented graphically and are discussed. For studies of vibration in a water flow, positions were selected for the application of strain gages, the relations between the relative bending strain and the deflection of the plate oscillating in the vibrational mode were determined. The technology and instrumentation as well as the pertinent data measuring and processing systems were tested in practical applications. (auth)

**24175** (SC-RR–720484) SPR II SYSTEM PARAMETERS. Bonzon, L. L.; Philbin, J. S. (Sandia Labs., Albuquerque, N. Mex.). Dec 1972. 57p. Dep. NTIS.

Recent SPR II parameter measurements are presented that supplement and extend previous data; these measurements also will aid in the design of advanced reactor concepts. Several newly measured system characteristics, specifically experimenter-oriented, are also detailed. (auth)

**24176** (SC-RR-720797) ANNULAR CORE PULSE REACTOR (ACPR) LOCAL VOID COEFFICIENT MEASUREMENTS. Rivard, J. B. (Sandia Labs., Albuquerque, N. Mex.). Nov 1972. 24p. Dep. NTIS.

Local, zero-power void coefficients of reactivity are determined from measurements of the reactivity worth of nitrogen flow in the Annular Core Pulse Reactor coolant channels. The coefficients are determined for several core locations and for differing void fractions. The coefficients for the normally configured core are negative. (auth)

**24177** (TM-61-12-3) HEAT TRANSFER ANALYSIS, LITR EXPERIMENT. Niemuth, W. E.; Pugh, R. A. (General Electric Co., Cincinnati, Ohio. Nuclear Materials and Propulsion Operation). 7 Dec 1961. Contract AT(40-1)-2847. 22p. Dep. NTIS. Declassified 3 Nov 1971.

**24178** APPLICATION OF MULTI-USERS ON-LINE SYSTEM TO NUCLEAR AND SOLID-STATE PHYSICS AT GATCHINA'S

**REACTOR WWR-M.** Kadashevich, V. I.; Kondurov, I. A.; Nickolaev, S. N.; Ryabov, Yu. F.; Vinogradov, V. I. (Nuclear Physics Inst., Leningrad). Comput. Phys. Commun.; 4: No. 3, 289-293(Dec 1972).

The on-line multi-users data-handling system in application to nuclear and solid-state physics is described. The computer-based system is designed for real-time experiments control and preprocessing. The system can meet simultaneously the demands of 24 users. (auth)

## Production Reactors

*Refer also to abstract 22932.*

**24179** (DUN-SA-194) CORROSION MONITORING IN N-REACTOR. Larrick, A. P.; Kratzer, W. K. (Douglas United Nuclear, Inc., Richland, Wash.). 14 Nov 1972. 55p. (CONF-730308-2). Dep. NTIS.

From 29th Annual National Association of Corrosion Engineers Symposium; Anaheim, California, USA (19 Mar 1973).

A "critical materials" list was compiled in 1963 to develop a corrosion monitoring program for alloys in the N-Reactor cooling systems. The list provided a number of specific environments in which the alloys were particularly susceptible to failure. Many of the alloys were included in the listing because specific quantitative information on their behavior at N-Reactor conditions was not available. In order to monitor the corrosive effect of the N-Reactor environments on these alloys, a series of in-reactor tests was approved permitting the exposure of samples in the primary, secondary, and graphite cooling systems. A set of five bypass loops was authorized in 1964 for installation in the three cooling systems to assess the effects of coolant chemistry, changes in operating conditions, off-standard operation, and decontamination on system materials. Since these loops could not be constructed in time to permit monitoring during the critical reactor startup period in late 1964 and early 1965, installation of samples in the downstream ends of the primary system Zircaloy-2 horizontal process tubes was authorized. Additional authorizations were obtained to allow monitoring stress corrosion cracking of copper alloys in the ammonia-contaminated air spaces around the reactor, monitoring of Zircaloy-2 corrosion in the graphite cooling system outlet nozzles, and monitoring of corrosion of several alloys in filtered Columbia River water. Results from these monitoring programs are presented. (auth)

## Reactor Components, Fuels, and Accessories

*Refer also to abstracts 22828, 22829, 22831, 22835, 22838–22840, 22845, 22857, 22916, 22923, 22926, 22927, 22941, and 22953.*

**24180** (CONF-720579-, pp 153-168) SODIUM LEAK AT THE FURNACE OF A LARGE SODIUM LOOP. Cleaning-up methods and attack of the combustion products on the constituents of the heating elements. Soenen, M. 1972.

From Meeting of specialists on sodium combustion and its extinguishment: techniques and technology; Richland, WA (22 May 1972).

The heater elements of a large sodium loop in the Technical Building at Mol developed a sodium leak. The cleaning-up operations and the effects of the combustion products on the cladding, solid nickel leads, and MgO insulation of the heating elements are described. It was concluded that the clean-up methods were inadequate, and that, once damaged by a sodium leak, the heaters and leads had to be replaced. Following this replacement, the heaters continue to operate satisfactorily after more than 6500 h. (LCL)

**24181** (CONF-721104-4) CORROSION CONSIDERATIONS IN LIGHT WATER-COOLED NUCLEAR POWER PLANTS. Paper Number 7. Cordovi, M. A. (International Nickel Co., Inc., New York). 1 Sep 1972. 35p.

From INCO Power Conference; Kyoto, Japan (28 Nov 1972).

# GENERAL

## Energy Economics

**24182** (BNWL-1694) ELECTRICAL LOAD FORECASTING. A Review. Reardon, W. A. (Battelle Pacific Northwest Labs., Richland, Wash.). 3 Nov 1972. Contract AT(45-1)-1830. 74p. Dep. NTIS $5.75.

All capacity planning by electric utilities must begin with a forecast of sales of electric energy. The perceived need then forms the basis of system planning. The purpose of this study is to examine the various methods of load forecasting used by electric utilities. A rather extensive survey of this sort was carried out by a panel assembled by the Federal Power Commission (The Methodology of Load Forecasting, 1969). This study, rather than repeat all that work, was devoted to determining if the methods had changed, determining what research is being carried out in the area, and looking into the factors that a utility considers when a capacity addition is to be made. These extensions carry into such areas as system reliability, reserve margins, uncertainties, etc. The economic factors of financial arrangements and corporate strategy are beyond the scope of this study. (auth)

**24183** (BNWL-SA-4060) EVALUATION OF ENERGY GROWTH AND USE TRENDS AS A POTENTIAL UPPER LIMIT IN METROPOLITAN DEVELOPMENT. Jaske, R. T. (Battelle Pacific Northwest Labs., Richland, Wash.). 8 Oct 1971. Contract AT(45-1)-1830. 31p. (CONF-711022-3). Dep. NTIS $3.75.

From 2nd annual thermal power and 8th biennial hydraulics conference; Pullman, Washington, USA (5 Oct 1971).

The case of energy use and distribution, as forecast from a composite of authoritative United States sources, illustrates that the extent of energy concentration in large metropolitan areas is expected to reach significant fractions of the solar input to the Earth's surface. Examinations of total energy release suggest direct relationship in weather modification of metropolitan areas such that mean temperature are increasing, cloudiness is increased, and total precipitation markedly increased. A tentative solution appears to include emphasis on metropolitan de-concentration of energy, people, and general industrial activity. A number of other alternatives such as higher rates, improved efficiency of generation and usage, and financial means of regulating supply, demand, and effects could also be suggested. Indispensable to all of these must be the development of a national land use policy. (JCW)

**24184** (CONF-730205-2) RESIDENTIAL DEMAND FOR ELECTRICITY. Tansil, J.; Moyers, J. C. (Oak Ridge National Lab., Tenn.). 1973. 17p. Dep. NTIS.

From Conference on energy, demand, conservation, and institutional problems; Cambridge, Massachusetts, USA (12 Feb 1973).

The growth of residential electricity use for the period 1950 to 1970 is examined from the standpoint of increases in the number of households, appliance saturations, and the average annual electricity consumption per appliance. Growth patterns defined illustrate the factors accounting for the increase from 1800 kWh per household in 1950 to 7000 kWh per household in 1970. Space heating, water heating, and air conditioning have small saturations, large average annual consumptions, and the greatest growth potentials for contributing to the residential load. Energy conservation is stressed through (1) the importance of housing insulation, (2) more efficient room air conditioners, and (3) the substitution of heat pumps for electric resistance heating. The number of households, appliance saturations, and average annual electricity use per appliance are projected to 1990 to obtain the total electricity consumption per appliance. The sum of the disaggregated projections is compared to other independent projections based on extrapolation and econometric methods. (auth)

**24185** (CONF-730205-3) OPPORTUNITY COSTS OF LAND USE: THE CASE OF COAL SURFACE MINING. Spore, R. L. (Oak Ridge National Lab., Tenn.). 1972. 17p. Dep. NTIS.

From Conference on energy, demand, conservation, and institutional problems; Cambridge, Massachusetts, USA (12 Feb 1973).

In general, two land use problems potentially are associated with coal surface mining: 1) external costs of production represented by adverse environmental impacts on neighboring sites, and 2) discrepancies between private and social evaluations of the opportunity costs of the development of land for coal surface mining. This paper addresses the latter problem, particularly as it may lead to the preservation of less than the socially optimal amount of natural environments. (auth)

**24186** (INIS-mf-249) SUPPLY OF NUCLEAR FUEL IN SWEDEN. (Industridepartementet, Stockholm (Sweden)). Dec 1971. 82p. (In Swedish). INIS.

A survey is given of different aspects of the supply of nuclear fuel in Sweden until the year 1990. The rapid increase of fuel consumption will motivate a decreased dependency on natural uranium import and such preparatory activities that a production factory can be ready by 1985 to produce uranium from the large but low-grade ore deposits in Mount Billingen. The search for new ore deposits shall continue. The enrichment is the most critical part of nuclear fuel supply both economically and politically. It is concluded that it is of great importance for Sweden to get access to the expected increase in enrichment capacity. If the centrifuge technique succeeds, the Swedish market will be large enough for such a plant in the 1980's. An outline is made for an organization, jointly owned by the government and the utilities, to purchase uranium and enrichment services on behalf of the utilities. Certain activities in the field might be fulfilled better by separate companies with other owners. In this way prospects will be created for an adequate balance between different measures in the nuclear fuel field and for collective actions against foreign suppliers and authorities. (JCW)

**24187** (JAERI-M-4799) COMPUTER CODE STRATEGY-LP FOR THE ECONOMETRIC EVALUATION OF NUCLEAR AND THERMAL POWER GENERATING INSTALLATIONS. Yasukawa, S. (Japan Atomic Energy Research Inst., Tokyo). Apr 1972. 34p. (In Japanese). NTIS (U.S. Sales Only).

The computer code STRATEGY-LP was prepared for the econometric evaluation of nuclear and thermal power stations. The code is capable of calculating the capacities of different types of power stations under the condition of minimum system power cost or fuel consumption. Features of the code are given. The code is written in FORTRAN-IV, and encoded for the IBM-360 (Model 75) digital computer. The time of computations is about 5 min for a standard problem. (JCW)

**24188** (LA-UR-73-73) MAGNETIC ENERGY STORAGE AND ITS APPLICATION IN ELECTRIC POWER SYSTEMS. Hassenzahl, W. V.; Rogers, J. D.; McDonald, T. E. (Los Alamos Scientific Lab., N. Mex.). 1972. 13p. (CONF-730306-2). Dep. NTIS.

From International convention and exhibition of the IEEE meeting; New York, New York, USA (26 Mar 1973).

The large capital expense of central power stations, such as coal-fired power plants, has led to the consideration of various types of energy storage for peak power shaving. Superconducting inductors with energy storage capacities of $10^{12}$ to $10^{13}$ J (the equivalent of 46 to 460 MW for a 6-h period) are discussed as an advanced energy storage system. Possible inductor configurations and their relative advantages are described. Preliminary estimates of capital and operating costs are given. (auth)

**24189** (ORNL-EIS-73-52(Vol.1)(No.3)) NSF-RANN ENERGY ABSTRACTS. (A Monthly Abstract Journal of Energy Research). Guthrie, M. P. (ed.) (Oak Ridge National Lab., Tenn.). Mar 1973. Contract W-7405-eng-26. 19p. Dep. NTIS $3.00.

Sixty-six abstracts are presented in the bibliography on energy sources, electric power (generation, supply and demand, transmission, environmental effects, and use), and energy (production, consumption, supply and demand, and policy). The research publications cited are technical journal articles, popular or semi-technical magazine articles, topical reports, progress reports, symposium papers and proceedings, monographs, and books published within the last two years. (JCW)

**24190** (UCRL-51315) OUR SOLAR ENERGY OPTIONS: PHYSICAL AND BIOLOGICAL. Tamplin, A. R. (California Univ., Livermore. Lawrence Livermore Lab.). 2 Jan 1973. Contract W-7405-eng-48. 23p. Dep. NTIS $4.00.

Various schemes that have been proposed for the utilization of solar energy are discussed. The first section discusses physical systems and the second section treats biological systems. The major focus of the report is to present a means of comparison; consequently, the technical description is somewhat brief. More detailed technical discussions can be found in the 56 cited references. (auth)

**24191** (WASH-1230(Vol.3)) COAL-FIRED FOSSIL PLANT. VOLUME III. 1000-MWe Central Station Power Plants Investment Cost Study. (United Engineers and Constructors Inc., Philadelphia, PA). Jun 1972. Contract AT(30-1)-3032. 126p. Dep. NTIS. $5.45.

Cost data for nuclear plant studies are presented in accordance with Appendix A of "Guide for Economic Evaluation of Nuclear Reactor Plant Designs," USAEC Report Number NUS-531; this guide was modified for the fossil plant studies. The intent of these studies is to present detailed cost information for a series of 1000-MWe electric generating plants to permit cost comparisons, evaluations and projections based on equivalent assumptions relative to site, labor, performance, and reference dates for cost data. The cost data included in these reports is based on prices effective as of January 1971, and reflects to the maximum extent actual construction experience for units nearing completion or in operation. (JCW)

**24192** SOCIAL, ECONOMIC, AND UTILITY GROWTH. Garvin, D. F. (Ebasco Services, Inc., New York). Pub. Util. Fortn.; 91: No. 4, 23-38(15 Feb 1973).

Social planning and social engineering are advancing in the nation today with little thought given to the economics involved. The ability of the USA to meet its future energy needs will be determined chiefly by the developments in technology—the technology of conversion and the technology of fuels acquisition. Utilization of the resources available is a costly problem. Their conversion into the stream of the economic and social life by means of capital, energy, labor, and efficient use also involves the rate of growth and total population. A report is given of electric companies' construction data, rate actions, and capacity. (JCW)

**24193** BALLOON-BORNE X-RAY MEASUREMENTS AT SODANKYLAE (FINLAND) IN JUNE, 1970. Lukkari, L. (Univ. of Oulu, Finland); Turunen, T.; Kangas, J.; Tanskanen, P.; Legrand, J. P. SPARMO Bull.; 5: No. 1, 5-15(Aug 1972).

Observational results of the balloon launching campaign in Finland in 1970 are given. X-ray measurements were made during a long-lasting disturbed period from June 17 to June 22. A new precipitation event superimposed on an SVA event after the ssc on June 18 is shown to have some characteristics typical for ssc-associated precipitation phenomena. (FR)

**24194** ENERGY IN THE SIXTH PLAN. Destival, C. Ind. Miner.; 59-62(Feb 1972). (In French).

The French energy requirements are fulfilled in the following manner: oil 60%, coal 25%, natural gas 6%, hydraulics 8%, and nuclear energy 1%. Oil is an abundant resource with a price increase that is not excessive; natural gas is a limited resource, coal production is in regression, while the exploitation of hydraulic power has reached its maximum. Electricity of nuclear origin is regarded as a long-term energy source. (FR)

**24195** NUCLEAR ENERGY IN THE USSR IN PERSPECTIVE. Peer, V. A. Energiewirt. Tagesfragen; 22: No. 11, 598(1972). (In German).

The main concepts for the use of nuclear power in the USSR are reported. It is intended, within the first stage, to construct large nuclear power plants with thermal breeder reactors until 1990. The further development is characterized by a continuously increasing number of fast breeder reactors. (GF)

**24196** UNITED STATES ENERGY. A Summary Review. Washington, DC; Department of the Interior (1972). 50p. GPO.

Today to supply adequate energy in the USA involves the development of the technology for a wise use of the energy resources available at a reasonable and competitive cost. National objectives include national security, conservation, environmental protection, consumer protection, and international trade. Energy requirements at the present time are discussed. Information on energy resources, their supply and demand, is summarized for electric power, coal, natural gas, petroleum, solar energy, controlled thermonuclear fusion, tidal energy, fuel cells, and geothermal energy. (52 references) (JCW)

**24197** FORECAST OF THE COAL AND URANIUM REQUIREMENTS FOR ELECTRIC POWER GENERATION IN SOUTH AFRICA. Maunders, E. J. (Atomic Energy Board, Pretoria). J. S. Afr. Chem. Inst.; 73: No. 1, 31(Aug 1972).

A computerized model is described of the South African electricity system developed jointly by the Atomic Energy Board and the Electricity Supply Commission. The results of an analysis of this system have been subjected to a fairly extensive sensitivity analysis that reveals that up to the year 1990 between 680 and 700 million tons of coal will be required for electric power generation, together with between 7,000 and 10,000 tons of uranium. This result is fairly insensitive to data variations, but the prediction of a cumulative requirement up to the year 2000, of between 1300 and 1800 million tons of coal and 25,000 to 70,000 tons of uranium, proves to be very data-sensitive. (auth)

**24198** GEOTHERMAL: EARTH'S PRIMORDIAL ENERGY. Bowen, R. G.; Groh, E. A. Technol. Rev.; 73: 42-48(1971).

Geothermal sources hold the potential for a significant increase in energy sources. The heat supply can only be exploited from the local hot spots—subterranean reservoirs where the heat has accumulated and is stored in the form of steam and hot water. Regions of high heat flow usually display hot springs, geysers, and fumaroles or steam vents. Productive results from exploration at such sites are represented by Larderello in Italy, Wairakei in New Zealand, and at the Geysers of California. Dry steam was reported from a well drilled in Valles Caldera, Sanoval Co., New Mexico. Hot brine with temperatures up to 650°F., has been produced at the Salton Sea area in Imperial Valley of southern California, and additional reservoirs are reported and being utilized by Mexico at an extension of the Imperial Valley. Japan and Iceland are using geothermal heating. Hungary and the USSR have reservoirs for development of the utilization of geothermal energy. The economics and environmental impact are discussed. (JCW)

**24199** PRIVATE POWER INDUSTRY FACED WITH THE NUCLEAR POWER ERA. Agrenius, G. Sv. Kraftverksfoereningens Publ.; No. 5, 37-61(1972). (In Swedish).

Forecasts of the demand for energy in Sweden are presented. The organization of the power industry is outlined and cooperation between governmental organizations and private consortia is discussed. Plans for reconstruction of Atomkraftkonsortiet to a joint-stock company representing the private Swedish nuclear industry are presented. (FHS)

**24200** ENERGY AT BARGAIN PRICES. Ejerhed, A.; Norhammar, U.; Wijkman, L. (eds.). Stockholm; Swedish Engineer's Press Ltd. (1972). 79p.

Proposals were submitted to the contest "Energy at Bargain Prices" arranged by the Svenska Teknologföreningen in order to bring out new and unconventional ideas about how to use waste heat from power production. (auth)

**24201** ENERGY AND OUR FUTURE. Seaborg, G. T. (Univ. of California, Berkeley). Pub. Util. Fortn.; 91: No. 3, 13-17 (1 Feb 1973).

The wise use of energy can restore nature, help clean up the environment, and rebuild cities. It can help toward a lasting peace and push to new frontiers, not only in space but in the mind and spirit of man. In the past, not enough thought was given to equally balancing the use of energy with proper environmental values. There is evidence that this is now changing. (auth)

**24202** ROLE OF NUCLEAR ENERGY IN PRESERVING ENVIRONMENTAL VALUES. Balzhiser, R. E. (Office of Science and Tech., Washington, DC). Pub. Util. Fortn.; 91: No. 3, 18-22 (1 Feb 1973).

The harmonious co-operation of the White House, Congress, the energy industry, environmental and consumer groups, and the general public will be needed to solve the energy problems. An understanding of the interrelationship among energy, environment, and economics is essential. An Office of Science and Technology energy review has indicated that nuclear power is the most viable energy form to meet future needs. (auth)

**24203** ENERGY AND THE ENVIRONMENT: A LONG-RANGE FORECASTING STUDY. Smil, V. J. University Park, PA; Pennsylvania State Univ. (1972). 272p. University Microfilms Order No. 72-33,204.

Thesis (Ph.D.).

A relatively concise overview of potential developments in energy industries and their multitudinous environmental impacts was made. While specialized engineering analyses of past trends abound, and descriptions of environmental consequences of energy production have become increasingly common in the last several years, broad, long-range inquiries into the future of energy and environment are very rare. Although necessary as a base, it was felt that any attempt to fill this gap could not just be based on a summary and evaluation of the piecemeal information widely scattered through the many current publications dealing with energy and environment. A complex and original long-range forecasting study seemed to be needed. The conclusions and recommendations given are, thus, to a large degree based on the results of the first international long-range forecasting study of Energy and the Environment. The Delphi forecasting method was employed successfully in this study, where forty experts from seven nations participated in three rounds of questioning lasting almost a year. Delphi provided results in four separate, though highly interrelated, areas of interest. Long-range probability forecasts were obtained for thirty energy production, transmission, and transportation technologies and thirty-one environmental protection, planning and management innovations. Percentage probabilities of five environmental episodes—urban air pollution, power supply failure, jumbo tanker wreck, offshore drilling oil spill, nuclear radiation contamination—were estimated for the 1970's. Finally, a relative ranking of the twenty-five most important energy–environment problems was established by the iterated Delphi procedure, and future growth limits of seventeen contemporary technologies were forecast by the energy systems experts. (Diss. Abstr. Int., B)

**24204** ENVIRONMENTAL ASPECTS OF NUCLEAR ENERGY. Landis, J. W. (American Nuclear Society, Hinsdale, IL). At. Jap.; 16: No. 4, Suppl., 5-56(Apr 1972). (CONF-720341-1).

From 5th Annual Conference of the Japan Atomic Industrial Forum; Tokyo, Japan (22 Mar 1972).

Atmospheric pollution is the most apparent and the most harmful effect of combustion of fossil fuel. Current free world demand for oil is about 40 million barrels a day. This means that there is only a 34 to 100 year supply, assuming no increase in the demand. Similar pictures for the availability of coal and natural gas exist. The most obvious environmental advantage of nuclear energy is total absence of combustion products and therefore atmospheric contamination. Another advantage of the nuclear energy is reduced capacity required for transportation and storage facilities. A third advantage of nuclear energy is vast amounts of fuel reserves in the crust of the Earth. But nuclear energy systems have certain disadvantages such as the discharge of waste heat, routine emission of radioactive material, unusual safety problems, and disposal of high-level radioactive wastes. And when high-temperature gas-cooled reactors are developed and operated, their waste heat and radioactive effluent will be smaller than that of light water reactors. Nuclear fusion reactors are promising because they discharge no radioactive wastes. (Japan)

**24205** NUCLEAR POWER: THE ELECTRIC INDUSTRY'S BEST HOPE FOR THE FUTURE. Zitlau, W. A. (San Diego Gas and Electric Co., CA). Pub. Util. Fortn.; 91: No. 7, 110(29 Mar 1973).

The advocation of the use of natural gas as a primary source of energy for air pollution control is unthinkable, when there is nuclear power available. Fossil fuels are too precious and exhaustible. The use of natural gas is indiscriminate most times for inferior purposes. The use of natural gas as boiler fuel is most inefficient. Rapid expansion and use of nuclear energy for power generation is urgent. Other alternative sources of energy for power generation include fusion power, solar energy, and geothermal resources. (JCW)

**24206** PERSPECTIVES ON POWER AND POLICY. SIMPSON, J. W. Pub. Util. Fortn.; 91: No. 7, 34-39(29 Mar 1973).

The shift to the electrical economy must be the core of a national energy policy, but the formulation of a meaningful policy may not come in time to avert a real energy crisis. The entire electric energy industry must act to develop strategy to meet the future energy demands. Substitutes must be found for gas and oil when possible. Coal is one substitute, electrical power from a nuclear energy base is another. (auth)

**24207** FACING THE ENERGY CHALLENGE. Warren, F. M. (Edison Electric Inst., New York). Pub. Util. Fortn.; No. 7, 31-33(29 Mar 1973).

In view of the many dimensions of the energy challenge, it is better to have the widespread interest in what is being done to avert a true energy crisis than have the lack of attention that existed when electricity and other forms of energy were taken for granted. Co-ordination of nationwide energy policies is urgently needed. Confusion and contradictions must be eliminated. (JCW)

**24208** GAS FROM COAL. Papamarcos, J. Power Eng.; 77: No. 2, 32-39(Feb 1973).

Coal gasification work has progressed to the point where important developments may be expected in rapid succession. Only one of the processes described here is considered commercial at this time, but the incentives are great to prove out others which may be more economical. (auth)

## Information Handling

*Refer also to abstract 22637.*

## Law

**24209** (CONF-710847-, pp 391-394) AN EXAMPLE TO ILLUSTRATE A COMPLICATED LEGISLATION BY FLOWSHEET. Viitaniemi, T. J. (Inst. of Radiation Physics, Helsinki). 1971.

From 3rd Nordic Radiation Protection Conference; Copenhagen, Denmark (18 Aug 1971).

In Proceedings of the 3rd Nordic radiation protection conference, Copenhagen, August 18-20, 1971.

The legislation on radiation protection in Finland includes such concepts as the exempted amount of activity, obligation to declare, exemption by inspecting, type of inspection, and obligation to have a permit. For those who begin to use ionizing radiation it is difficult to find out what regulations are valid for different radiation sources e.g., color television sets, legal gauges, smoke detectors, and dental radiography units. To ease the situation, two flowsheets are presented. One is for devices that produce x rays and the other for radioactive substances. With these flowsheets it is easy to demonstrate the category of various devices and other radiation sources. (auth)

**24210** TRANSGRESSION OF THE ATOMIC ENERGY LAW. Energiewirt. Tagesfragen; 22: No. 8-9, 468-469(1972). (In German).

Reasons for a judgement passed by a Criminal Court of the Landgericht Karlsruhe which dismissed the action in the court of appeals are given. The appeal was lodged by one of the two defendants who were accused for having wiped their protective gloves, covered with the dangerous plutonium particles, on an air filter, thus causing radioactive contamination of the laboratory and exposing their colleagues to the danger of being contaminated. (INIS)

## Management

**24211** (AEC-tr-7400) NUCLEAR ENGINEERING BUSINESS. Order of Business, 24 October 1972. Translated from German. 3 Nov 1972. 5p. Dep. NTIS.

The order of business of the Nuclear Engineering Committee under the Federal Minister of Education and Science of the German Federal Republic is presented. An attached memorandum on problems in West German reactor installations details the date, nature of the problem, radioactivity release, and personnel damage from 6 events at 5 reactors. (LCL)

**24212** (GAT-371(Rev.1)) A GUIDE TO NUCLEAR SAFETY: PORTSMOUTH AREA GASEOUS DIFFUSION PLANT. (Goodyear Atomic Corp., Piketon, Ohio). Jul 1972. Contract AT(33-2)-1. 35p. Dep. NTIS.

The principal operation at the Portsmouth Gaseous Diffusion Plant is the separation of the fissionable isotope uranium-235 from its mixtures with the more plentiful uranium-238. Improperly handled uranium material might go critical, causing serious radiation exposures to personnel and property damage. Nuclear safety, which encompasses efforts to prevent such occurrences, is a major consideration in plant operations. For all activities in which accident prevention is of vital interest to all concerned, there are specific safety rules for the prevention of each particular type of accident. So it is in the case of nuclear safety. Large amounts of critical mass research data have enabled unsafe situations to be defined. As a result, nuclear safety rules to protect personnel and plant property against this special hazard were written. This pamphlet was prepared to help personnel understand what nuclear safety is and the part they play in making GAT a safe place in which to work. (auth)

## Mathematics and Computers

*Refer also to abstract 24187.*

**24213** (BNWL-1700) DATA COLLECTION SYSTEM UTILIZING CASSETTE TAPE STORAGE. Hof, P. J.; Erickson, M. D. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Dec 1972. Contract AT(45-1)-1830. 57p. Dep. NTIS. $5.75.

A general-purpose data-acquisition system was developed utilizing cassette tape storage. The design requirements for the system included modularity, portability and general-purpose features making it usable on a wide variety of data-collection applications. The engineering evaluation prototype was developed for the purpose of determining cost effectiveness and technical feasibility for use in a production environment. Initial application involves obtaining weapons fabrication data from production agencies in order to establish a data base to be used for quality assurance and other long-term studies. (auth)

**24214** (BNWL-B-115) PACKARD 45 TO DECTAPE COUPLER. Ratcliffe, C. A. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Aug 1971. Contract AT(45-1)-1830. 40p. Dep. NTIS.

**24215** (COO-1469-215) NUMERICAL SYSTEMS ON A MINICOMPUTER. Brown, R. L. Jr. (Illinois Univ., Urbana. Dept. of Computer Science). Feb 1973. Contract AT(11-1)-1469. 46p. (UIUCDCS-R-73-555). Dep. NTIS.

The concept of a numerical system for a minicomputer is defined and a description is given of the software and computer system configuration necessary to implement such a system. A procedure for creating a numerical system for a FORTRAN program is developed and an example is presented. (MOW)

**24216** (COO-3288-24) PRODUCTION SYSTEMS: A FORMALISM FOR DEFINING THE SYNTAX AND TRANSLATION OF PRACTICAL PROGRAMMING LANGUAGES. Ledgard, H. F. (Johns Hopkins Univ., Baltimore, MD). Dec 1972. Contract AT(11-1)-3288. 59p. Dep. NTIS.

Application of a formalism called production systems to define the syntax of a computer language and its translation into a target language is investigated. Several properties appear well-suited to this task: (a) The formalism can be used to specify exactly the syntax of a computer language, including context-sensitive requirements. (b) The specification of the context-free portions of syntax and the context-sensitive portions of syntax can be isolated. (c) The same formalism can be used to specify the translation of a language into another. The following example applications of production systems are given: (a) a specification of the syntax of a significant subset of PL/I; (b) a specification of the abstract syntax of the PL/I subset; and (c) a specification of the translation of lambda-calculus expressions into normal form. (auth)

**24217** (IAE-2196) TOWARD A STATISTICAL THEORY OF ONE DIMENSIONAL SYSTEMS. Bortsaikin, S. M.; Mikhailova, Yu. V. (Institut Atomnoi Energii, Moscow (USSR)). 1972. 23p. (In Russian). Dep. NTIS (U.S. Sales Only) $3.25.

**24218** (JUL-880-MA) ITERATIVE SOLUTION OF LINEAR INEQUALITIES. Eckhardt, U. (Kernforschungsanlage, Juelich (West Germany). Zentralinstitut fuer Angewandte Mathematik). Aug 1972. 85p. (In German). Dep. NTIS (U.S. Sales Only).

Thesis. Submitted to Technische Hochschule, Aachen (West Germany).

**24219** (LA-5163) SOURCE SAMPLING IN THE FLASH MONTE CARLO COMPUTER CODE. Sandford, M. T. II (Los Alamos Scientific Lab., N. Mex.). Jan 1973. Contract W-7405-eng-36. 6p. Dep. NTIS.

An estimator algorithm for obtaining the volume source score in the backward Monte Carlo method is presented. The algorithm given uses vector geometry to obtain greater efficiency than the one utilized by Collins and Wells in the original FLASH code. The vector method is easily extended to estimate the score from other source geometries. (auth)

**24220** (SC-DR-720830) DIGITAL DATA-HANDLING SYSTEM FOR THE GENERAL UNDERWATER LIGHT PROJECT (GULP). Miyoshi, D. S. (Sandia Labs., Albuquerque, N. Mex.). Feb 1973. 25p. Dep. NTIS.

Design details of the digital data-handling system, which is the most complex part of the instrumentation used for the General Underwater Light Project (GULP), are described. Light gathered by the radiometer optics is focused onto a photomultiplier tube operated in a pulse-counting mode. The output of the photomultiplier tube is then processed to give a count-rate distribution that is displayed on an oscilloscope in the manner of a pulse-height analyzer. The digital data-handling system has been used to signal-average, to detect the presence of a non-Poisson light source such as bioluminescence, and to discriminate against bioluminescent flashes that would otherwise mask a steady-state source. (auth)

**24221** (SCL-DR-720370) REHRAT: A PROGRAM FOR BEST MIN-MAX RATIONAL APPROXIMATION. Huddleston, R. E. (Sandia Labs., Livermore, Calif.). Dec 1972. Contract AT(29-1)-789. 34p. Dep. NTIS.

Assume that F is a function defined on the interval [a,b] for which one may compute values accurately but not cheaply. A proven method for efficiently computing many such functions is to replace it with a rational function R(x) (a quotient of two polynomials) which is optimal in a min-max sense. In this document, a brief tutorial is given on best min-max rational approximation and a program is presented for determining such approximations. (auth)

**24222** (SLA-73-72) CDC 6600 CODES FOR BESSEL FUNCTIONS $I_\nu(x)$, $\mathrm{ber}_\nu(x)$, $\mathrm{bei}_\nu(x)$ AND RATIOS $I_{\nu+1}(x)I_\nu(x)$. Amos, D. E.; Daniel, S. L. (Sandia Labs., Albuquerque, N. Mex.). Jan 1973. 46p. Dep. NTIS.

This report documents subroutines IBESS, BERBEI and RIBESS for N member sequencies $I_{\nu+k}(x)$, $\mathrm{ber}_{\nu+k}(x) + i\,\mathrm{bei}_{\nu+k}(x)$, and $r_{\nu+k}(x) = I_{\nu+k+1}(x)/I_{\nu+k}(x)$, $k = 0,1,\ldots,N-1$ respectively for $x \geq 0$ and $\nu \geq 0$. An additional routine called SIBESS is also described which allows scaling in the form $\exp\{g(x)\}[h(x)]^\nu I_\nu(x)$ with no additional exponential or logarithm evaluations. Uniform asymptotic expansions in conjunction with series and backward recursion are the main tools for $I_{\nu+k}(x)$ and $\mathrm{ber}_{\nu+k}(x) + i\,\mathrm{bei}_{\nu+k}(x)$. A rapidly convergent algorithm which does not require Bessel function evaluations is used for $r_{\nu+N-1}(x)$. Backward recursion generates the remaining members of the $r_{\nu+k}(x)$ sequence. (auth)

**24223** (TID-26281) GENERALIZED INTERACTIVE NETWORK ANALYSIS AND SIMULATION SYSTEM. Gear, C. W. (Illinois Univ., Urbana. Dept. of Computer Science). 1971. Contract AT(11-1)-1469. 32p. Dep. NTIS.

A generalized network analysis — continuous system simulation system — is being constructed at the University of Illinois. The system allows the user to define general elements. These elements consist of a set of terminals (connection points) and a set of state equations. The elements can be connected together in networks and subjected to steady-state or transient analysis. The network is expanded into a system of equations which is manipulated symbolically for partial simplification. The resulting equations are then compiled into machine-language subroutines. These subroutines are used first by a sparse matrix analyzer which determines the structure of the Jacobian of the system and performs a "symbolic" LU decomposition to generate inline code for multiplying by the inverse of the Jacobian. These codes are used by the numerical integration package. (auth)

**24224** (UCRL-74373) MEASUREMENT OF LAWRENCE LIVERMORE LABORATORY CDC-7600 SYSTEM PERFORMANCE. Sutherland, G. G. (California Univ., Livermore. Lawrence Livermore Lab.). 18 Dec 1972. 19p. (CONF-730207-1). Dep. NTIS.

From SICME symposium 1973; Palo Alto, California, USA (26 Feb 1973).

Performance measures of machine utilization are done on a continuing basis at Livermore. A brief description of the sampling and presentation techniques is given. The impact of timesharing and heavy I/O loading is shown graphically. (auth)

**24225** (Y-1878) AUTOMATIC PROGRAMMER FOR AN ELECTRON BEAM WELDER. Burkhardt, J. H. Jr.; Davenport, C. M.; Gray, D. H. (Oak Ridge Y-12 Plant, Tenn. (USA)). 14 Mar 1973. Contract W-7405-eng-16. 23p. Dep. NTIS $4.00.

A medium-sized computer was interfaced to a 6-kw electron-beam welder to provide automatic programming of weld parameters for single and multipass welds. Changes in six parameters are synchronized to the position of the part being welded. (auth)

## Miscellaneous

**24226** (AECL-4312) SEASONAL ABUNDANCE AND VERTICAL DISTRIBUTIONS OF CRUSTACEAN ZOOPLANKTON IN A COLOURED DYSTROPHIC LAKE IN NORTHEASTERN ONTARIO. McMahon, J. W. (Atomic Energy of Canada Ltd., Chalk River, (Ontario). Chalk River Nuclear Labs.). Jan 1973. 28p. Dep. NTIS (U. S. Sales Only). AECL $1.00.

**24227** (ANL-7999) LITHIUM/CHALCOGEN SECONDARY CELLS FOR COMPONENTS IN ELECTRIC VEHICULAR-PROPULSION GENERATING SYSTEMS. Interim Technical Summary Report No. 5 for May 23, 1971–November 22, 1971. Walsh, W. J.; Gay, E. C.; Arntzen, J. D.; Kincinas, J. E.; Cairns, E. J.; Webster, D. S. (Argonne National Lab., Ill.). Jan 1973. Contract W-31-109-eng-38. 40p. Dep. NTIS $4.00.

For Army Mobility Equipment Research and Development Center, Fort Belvoir, Va.

**24228** (AWRE-O-48/72) COMPUTER PROGRAM TO DETERMINE THE SPECTRUM AND A DISPERSION CHARACTERISTIC OF A TRANSIENT SIGNAL. Burton, P. W.; Blamey, C. (Atomic Weapons Research Establishment, Aldermaston (England)). Sep 1972. 74p. Dep. NTIS (U. S. Sales Only). UK pounds 1.50.

**24229** (BDX-613-775) CABLE FABRICATION AND ENCAPSULATION, FY73-1. Husby, T. J. (Bendix Corp., Kansas City, MO). Feb 1973. Contract AT(29-1)-613. 27p. Dep. NTIS.

**24230** (BDX-613-776(Rev.)) HIGH-DENSITY BRAID CABLE SHIELDS, FY72-4. Quarterly Report. Edwards, H. J. Jr. (Bendix Corp., Kansas City, MO). Mar 1973. Contract AT(29-1)-613. 25p. Dep. NTIS.

**24231** (BMBW-FBK-72-27) RESEARCH AND DEVELOPMENT ARRANGEMENTS IN THE FIELD OF DESALINATION OF SEAWATER. (Battelle Institut E. V., Frankfurt Am Main (West Germany)). Dec 1972. 291p. (In German). Dep. NTIS (U. S. Sales Only) $16.75.

**24232** (BNL-17588) UPLAND RECHARGE PROJECT. Small, M. M. (Brookhaven National Lab., Upton, N. Y.). 1 Feb 1973. 19p. Dep. NTIS $3.00.

**24233** (BNWL-1681) UPPER CONFIDENCE LIMIT TABLES FOR THE HYPERGEOMETRIC DISTRIBUTION. Stewart, K. B. (Battelle Pacific Northwest Labs., Richland, Wash.). 15 Jan 1973. Contract AT(45-1)-1830. 78p. Dep. NTIS $5.45.

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Thesis.

**24258** (JINR-P11-6816) STATISTICAL METHOD OF FITTING. Eler, G. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1972. 15p. (In Russian). Dep. NTIS (U. S. Sales Only).

**24259** (KFK-EXT-6/71-3) QUANTITATIVE IMAGE ANALYSIS USING ELECTRONIC IMAGE ANALYZERS. Ondracek, G. (comp.) (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Material und Festkoerperforschung). Dec 1971. 109p. (In German). INIS.

**24260** (LA-5151) $CO_2$ GAS LASER STUDIES. Mills, C. B. (Los Alamos Scientific Lab., N. Mex.). Jan 1973. Contract W-7405-eng-36. 37p. Dep. NTIS.

Laser gain measurements were used to improve published molecular vibration excitation and relaxation rates for a $CO_2$-gas, electron-beam-controlled, laser amplifier. The equations of plasma current continuity and molecular excitation energy conservation were solved for cold, dense (STP), gaseous plasma, and the populations of excited levels were used to compute laser gain as a function of time. Parametric differences from experiment for a wide range of He, $N_2$, and $CO_2$ gas mixtures, over the range of plasma currents of 1 to 10 amp $cm^{-2}$ and potential gradients of 1 to 10 kV $cm^{-1}$, permitted the improvement of rate constants available from other work. Errors in laser gain as a function of time are ±10% for a wide variety of conditions with the modified rate constants. The plasma current computed agreed well with measurements for the developing plasma, and the cathode sheath potential drop was shown to be 400 to 2400 volts, consistent with experimental inference. (auth)

**24261** (LA-5166-MS) LASER MODULATOR. Rupert, G. N.; Newkirk, L. R. (Los Alamos Scientific Lab., N. Mex.). Feb 1973. Contract W-7405-eng-36. 4p. Dep. NTIS $3.00.

**24262** (LA-5168-MS(Pts. 1 and 2)) INSTRUMENTATION FOR HIGH TEMPERATURE CHEMICAL PROCESS CONTROL. Part I. Digital Readout for Optical Pyrometer. Part II. Periodically Sensing Alarm System. Rupert, G. N.; Wallace, T. C. (Los Alamos Scientific Lab., N. Mex.). Feb 1973. Contract W-7405-eng-36. 6p. Dep. NTIS $3.00.

**24263** (LA-5181-MS) SENSITIVE OPTICAL PHOTOMETER FOR USE AT 1.27 MICRONS. Metzger, D. S.; Manning, J. P. (Los Alamos Scientific Lab., N. Mex.). Feb 1973. Contract W-7405-eng-36. 8p. Dep. NTIS $3.00.

**24264** (LA-5200) MANHATTAN DISTRICT HISTORY. Non-scientific Aspects of Los Alamos Project Y, 1942-1946. Truslow, E. C. (Los Alamos Scientific Lab., N. Mex.). Mar 1973. Contract W-7405-eng-36. 117p. Dep. NTIS.

Recent wide interest by historians about this era has led the Los Alamos Scientific Laboratory to issue this edited version of an unpublished volume covering the construction, organization, and personnel of Project Y. An Appendix covering some early experiences at S Site has been added. (auth)

**24265** (LA-DC-72-1483) THRUST STAND PERFORMANCE MEASUREMENTS OF A LITHIUM-FUELED APPLIED-FIELD MPD ARCJET. Fradkin, D. B.; Roehling, D. J. (Los Alamos Scientific Lab., N. Mex.). [nd]. 16p. (CONF-730311-1). Dep. NTIS.

From 13th symposium on engineering aspects of magnetohydrodynamics; Stanford, California, USA (26 Mar 1973).

The performance of a steady-state lithium-fueled applied-field MPD arcjet is evaluated from the direct measurement of thrust using a unique parallel pendulum thrust stand having a sensitivity of better than .05N. The arc operates at input electrical powers of between 10 and 25 kW, with currents between 300 A and 550 A, input mass flow rates of between 23 and 41 mg/sec, and applied field strengths of between 900 and 2700 G. It is found that the thrust correlates with the product $IB_z$, where I is the arc current and $B_z$ the applied magnetic field strength. Thrust densities at the anode exit plane as high as 500 N/$m^2$ are observed. The effective exhaust velocity, or equivalently the $I_{sp}$, depends on the quantity $IB_z/\dot{m}$; $\dot{m}$ being the input lithium mass flow rate. Effective exhaust velocities as high as $2 \times 10^4$ m/sec are observed. Thrust efficiency, the ratio of the total power producing thrust to the total electrical input power, increases linearly with $I_{sp}$ reaching 35% at the highest measured $I_{sp}$ of 2050 sec. Possible mass entrainment effects on the measurements are considered. (auth)

**24266** (LA-UR-73-60) REPORT ON NOISE AND VIBRATION REDUCTION OF A HYDRAULIC SYSTEM. Wilson, A. R.; Grauerholz, G. F. (Los Alamos Scientific Lab., N. Mex.). [nd]. Contract W-7405-eng-36. 8p. (CONF-721072-1). Dep. NTIS.

From IMOG machine tool subgroup maintenance seminar; Oak Ridge, Tennessee, USA (3 Oct 1972).

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**24268** (NRC-TT-1621) TRANSCUTANEOUS INDUCTIVE TRANSMISSION OF EMG (ELECTROMYOGRAM) SIGNALS. Becker, W.; Englehardt, A.; Sorel, F.; Schlittenhardt, P.; Wehner, E. Translated by K. Fracke from Electromedizin; 15: No. 3, 118-123(1970). 10p. Dep. NTIS (U. S. Sales Only).

**24269** (ORNL-tr-2667) IMMUNOSEROLOGICAL, CLINICAL, AND HISTOPATHOLOGICAL STUDIES OF PLACENTAL PROTEIN OF RABBITS AND RATS. Hayashi, A. Translated by Hisashi Kubota (Oak Ridge National Lab., Tenn.), from Nippon Sanka Fujinka Gakkai Zasshi; 21: 309-318(1969). 27p. Dep. NTIS.

**24270** (RHEL/R-259) GRAPHIC REPRESENTATION OF FUNCTIONS OF TWO VARIABLES. Barlow, J.; Franek, B. (Rutherford High Energy Lab., Chilton (England)). Aug 1972. 41p. Dep. NTIS (U. S. Sales Only) $4.25. UK 50 pence.

**24271** (RLO-2228-T-1-5) HIGH-TEMPERATURE OXIDATION OF IRIDIUM. Third Annual Progress Report. Wimber, R. T. (Montana State Univ., Bozeman. Dept. of Mechanical Engineering). Feb 1973. Contract AT(45-1)-2228. 31p. Dep. NTIS $3.75.

The experimental results for the oxidation of iridium wires in undiluted, naturally convected oxygen have been theoretically correlated with a good deal of success. Preliminary, partially optimized, new values for the vapor pressure of iridium and the standard-state entropies and enthalpies of formation of $IrO_2$ and $IrO_3$ have been obtained. (auth)

**24272** (SC-DR-720790) MULTICONDUCTOR TRANSMISSION LINE FREQUENCY RESPONSE ANALYSIS AND DATA: A STATUS REPORT. Cooper, J. A.; Parker, R. L.; Steigerwald, G. A. (Sandia Labs., Albuquerque, N. Mex.). Feb 1973. 63p. Dep. NTIS.

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**24274** (SLA-73-153) COMPUTER CODES FOR POWER AMPLIFIER DESIGN. Webb, J. G. (Sandia Labs., Albuquerque, N. Mex.). Feb 1973. 28p. Dep. NTIS.

**24275** (UCLA-10-P-14-116) ACTIVITY TRANSFORMATIONS ON GRAPH MODELS OF PARALLEL COMPUTATIONS. Fernandez, E. B. (California Univ., Los Angeles. Dept. of Computer Science). Oct 1972. Contract AT(11-1)-Gen-10. 88p. (UCLA-ENG-7287). Dep. NTIS.

**24276** (UCRL-51277) TWTD: A COMPUTER PROGRAM FOR THE TIME-DOMAIN ANALYSIS OF THIN-WIRE STRUCTURES. Van Blaricum, M.; Miller, E. K. (California Univ., Livermore. Lawrence Livermore Lab.). 28 Oct 1972. Contract W-7405-Eng-48. 124p. Dep. NTIS (U.S. Sales Only).

**24277** (UCRL-51320) ACOUSTIC EMISSION SENSORS AND INSTRUMENTATION. Tatro, C. A. (California Univ., Livermore. Lawrence Livermore Lab.). 3 Jan 1973. Contract W-7405-eng-48. 23p. Dep. NTIS.

**24278** (UCRL-74400) PERFORMANCE MEASUREMENTS IN LLL OCTOPUS COMPUTER NETWORK. Mendicino, S. M.; Sutherland, G. G. (California Univ., Livermore. Lawrence Livermore Lab.). 27 Feb 1973. 5p. (CONF-730208-1). Dep. NTIS.

From Computation conference; San Francisco, California, USA (27 Feb 1973).

**24279** (UCRL-74436) TRANSMISSION LINE PARAMETER MEASUREMENT. Noel, R. J. (California Univ., Livermore. Lawrence Livermore Lab.). 12 Jan 1973. 9p. (CONF-730204-1). Dep. NTIS.

From Symposium on IEMP; San Diego, California, United States of America (USA) (6 Feb 1973).

**24280** (UCRL-Trans-10661) WAVES IN CONTINUOUS MEDIA. Nonstationary Shock Waves and Strength Improvement. Nigmatulin, R. I.; Kholin, N. N.; Skugorova, N. F. (Moscow State Univ. (USSR)). 1970. Translation of Report No. 1081. 81p. Dep. NTIS.

**24281** (UCRL-Trans-10663) UNIFORMIZING THE DISTRIBUTION OF ILLUMINATION AT THE OUTPUT OF A HIGH-POWER AMPLIFIER. Translated from Russian. 3 Oct 1972. 21p. Dep. NTIS.

**24282** (Y-SB-186) COMPILATION OF TECHNICAL PAPERS PRESENTED AT THE SME CLINIC ON PRECISION MACHINING AND GAGING, OAK RIDGE, TENNESSEE, NOVEMBER 14-16, 1972. Broders, M. A.; Whitten, L. G. Jr. (comps.) (Oak Ridge Y-12 Plant, Tenn. (USA)). 14 Nov 1972. Contract W-7405-eng-26. 384p. (CONF-721130). Dep. NTIS.

The Society of Manufacturing Engineers and Nuclear Division, Union Carbide Corporation co-sponsored a clinic on "Precision Machining and Gaging" that was held at Oak Ridge, Tennessee on November 14 to 16, 1972. The 34 technical papers presented at this clinic are listed in previous issues of NSA. For references to these see CONF-721130 in the Report Number Index. (TFD)

**24283** NUCLEAR ENERGY: ITS PHYSICS AND ITS SOCIAL CHALLENGE. Inglis, D. R. Addison-Wesley Series in Physics. Reading, MA; Addison-Wesley Publishing Company (1973). 406p.

The text provides a view of both the scientific and the humanistic aspects of nuclear energy problems. The overriding aim of the book is to provide the foundation for understanding both the technical and the sociopolitical sides of nuclear problems—for a reader without prior knowledge of either. The presentation of physical principles is elementary and as brief as possible, the discussion being confined to concepts essential to an understanding of nuclear reactors and weapons. The book covers with an economy but sufficiency of detail the whole subject of nuclear energy—from reactors and bombs with their potential benefits and dangers to their associated ecological effects and medical and industrial spinoffs. In addition to the basic presentation in nine chapters, a wealth of supplementary material is available in eighteen appendices, divided about equally between scientific and sociopolitical subjects. (JCW)

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